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FINAL EVALUATION OF THE USAID MOROCCO LOCUST CONTROL PROJECT
(No. 608-0196)

March 1992

DEVELOPMENT ASSISTANCE CORPORATION

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

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PREFACE

An "end of project evaluation" is a regular procedure for all USAID projects and was one of the activities foreseen under the USAID Morocco Locust Control Project (MLCP). In response to USAID's request to undertake such an evaluation, Development Assistance Corporation in collaboration with Winrock International Institute for Agriculture Development provided a team of five experts, each of whom dealt with a different aspect of the MLCP. These experts included:

Habib Khoury	Evaluation Specialist/Team Leader
George Cavin	Entomologist/Locust Specialist
Ellis Huddleston	Pesticide Management Specialist
Carrol Voss	Operation/Application Specialist
Wolfgang Mueller	Environmental/Health Specialist

All team members would like to express their gratitude to the Moroccan authorities for their help and collaboration, and to all officials interviewed for their patience and the time they devoted to meeting with team members. Without their contributions, a thorough evaluation would not have been possible. The team would also like to extend its gratitude to USAID/Rabat for all of the assistance they provided to the team, and to DAC and Winrock International for their oversight of the activity. Special thanks is given to Mr. Joseph Kitts, Project Coordinator, for the many hours he spent with the team in Rabat and in the field, providing a great deal of information and access to critical personnel and places. His frank and open answers to the team's many questions and inquiries were especially appreciated. Finally, the team wishes to express its gratitude to Said Ghaout, from the Moroccan Crop Protection Service (DPV), for his assistance in providing documents and arranging meetings.

ACRONYMS

AchE	Acetylcholinesterase
ADO	Agriculture Development Officer (USAID)
AFR	Africa Bureau (USAID)
BHC	Benzene hexachloride (= HCH)
CP	Command Post
DAC	Development Assistance Corporation
DDVP	Dichlorovinyl Dimethyl Phosphate (Dichlorovos)
DL	Desert Locust
DPV	Direction de la Protection des Végétaux
DWRC	Denver Wildlife Research Center
ECLC	Emergency Center for Locust Control
Envir.	Environment or environmental
EPA	Environmental Protection Agency (U.S.)
FAO	Food and Agriculture Organization (United Nations)
FMI	Force Maghrébine d'Intervention
GOM	Government of Morocco
GR	Gendarmerie Royale
HCH	Hexachlorocyclohexane (= BHC)
MARA	Ministry of Agriculture and Agrarian Reform
MOR	Morocco
NCLC	National Center for Locust Control
NIOSH	National Inst. of Occupational Safety and Health
NLCC	National Locust Control Center
NOLC	National Organization for Locust Control
OFDA	Office for Disaster Assistance (U.S.)
OPs	Organophosphates
OTA	Office for Technical Assistance (US Congress)
PC	Command Post
PCC	Central Command Post
PCR	Regional Command post
PID	Project Identification Document
PM	Person Month
PP	Project Paper
PPB	Part Per Billion
PPM	Part Per Million
RBC	Red Blood Cells
SPC	Sous-Post de Command
TA/T.A.	Technical Assistance
ULV	Ultra-Low Volume
UO	Operational Unit
US/U.S.	United States
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

This is the report on the "end-of-project" final evaluation of the Morocco Locust Control Project (MLCP), USAID No. 608-0196. The evaluation was carried out over a three and a half week period in February and March 1992, by a team of five experts selected by Development Assistance Corporation and logistically supported by Winrock International.

The project evolved from the first locust invasion in October 1987, at which time USAID invoked emergency relief through OFDA. A second invasion also required emergency relief through OFDA, and it appeared that locusts would continue to pose a serious threat to Moroccan agriculture over an extended period. In order to provide a mechanism for longer-term assistance, the MLCP was approved May 11, 1988 for $ 3.5 million with a PACD of Sept 30, 1990. Based on the expectation that a serious threat would continue through January 1990, the MLCP was amended on February 10, 1989 to increase the total budget to $ 23.5 million, and to extend the completion date to June 30, 1991. A continuing locust threat did not, however, develop, and of the Project's total budget, only the $5.7 million was expended. Due to the hiatus of USAID activities in Morocco during the Gulf War, the Project Activity Completion Date was, however, again extended to June 1992 in order to enure the adequate close-out of activities, including those related to environmental monitoring.

Within the above framework, the stated goal of the USAID Morocco Locust Control Project was "to protect Moroccan agricultural and livestock production from the locust plague in ways consistent with protecting the health and well-being of the people and the environment." The more specific project purpose was to assist the GOM, in coordination with other donors, to control the Desert Locust invasion.

Inputs provided by USAID included aircraft flying hours, insecticides, technical assistance, selected commodities, safety equipment, ground surveillance and communication equipment, and environmental monitoring systems. Intended outputs, included: 1) an enhanced capacity to control DL through aerial spraying of insecticides; 2) improved strategic planning and tactics of control, including preparation for appropriate responses north of the Atlas mountains; 3) improved efficiency of operations such as survey, treatment and communications; and 4) improved GOM capacity for the management and monitoring of environmental, safety and health aspects of control operations.

The evaluation methodology consisted of document reviews, field investigations in Morocco and interviews with US, Moroccan and international organizations. The project's logical framework, as presented in the Project Paper and subsequent amendments, was used as a principle point of reference for the team. In order to provide a sound structure to the evaluation, the team broke-down its work and the evaluation report into six principle areas, namely: the project's history and description; the organizational structure; survey and control strategies; issues related to operations and the application of pesticides; pesticide management and disposal; and human health and the environment. Other areas examined by the team and presented in this report include: USAID's responsiveness to the problem; human resource development; regional cooperation; the validity of economic assumptions in the Project Paper; and the cost of the locust control program. The team's development of lessons learned and recommendations are also

presented in detail.

Special mention should be made with regard to the OTA report entitled "A Plague of Locusts." Although the evaluation team had no specific mandate to address the issues of the report, which some have considered as critical of USAID's involvement in locust control programs, the team did recognize the importance of the same, and attempted to examine the areas of concern highlighted by OTA.

Principle Findings:

Overall, the team was most impressed with the quality and effectiveness of the MLCP, and project's goal of protecting in a safe manner Moroccan crops and livestock appears to have been well-achieved in that no significant damage to crops and livestock occurred, and no reports of serious harm to human health or the environment were registered. Moreover, with respect to each intended output, the teams findings were generally positive. Specifically, the following may be noted:

1) **Enhanced capacity to control DL through aerial spraying of insecticides:**

   During the three campaigns, Morocco treated in total about 4.8 million ha. using aerial and ground treatment against Desert Locust adults and hoppers. As concerns aerial spraying, the Moroccan operational capability clearly increased, from 2,000 ha. per day before the 1987 invasion to a peak average of about 32,300 ha. per day in November 1988, eventually accounting for about 77% of the total area treated. To this effort USAID supplied the flying hours of two Turbo Thrushes, two DC-7s and one C-130.

   An important aspect of the GOM's enhanced aerial spraying capacity, which reached 93.5% of the total area treated during the 1988 campaign, relates to the use of which larger aircraft, such as the USAID-provided DC-7s. These aircraft accounted for approximately 30% of total area sprayed, and it was only through the addition of these larger airplanes that it was possible to reach the capacity.

   It may be further noted that even though the registered increase was due in large part to donor assistance, the maintenance of personnel, equipment and material stocks has allowed the GOM to maintain this aerial treatment capability, which at the time of the evaluation was estimated to be about 20,000 to 30,000 ha. per day.

2) **Improved strategic planning and tactics of control, including preparation for appropriate responses north of the Atlas mountains:**

   The patterns of locust invasion in the spring and fall of 1988 came mainly from movement of swarms developed in northern Mauritania, while those that entered Morocco in early 1989 came almost entirely from along the coast. As demonstrated by the fact that swarms were eliminated before they could cross the Anti-Atlas mountains, the adopted control strategy which is discussed in detail in later sections was successful in providing Morocco the desired level of

protection to its crops. Though the failure of invasions to continue in the fall of 1989 and later did not allow a full test of GOM capacity, the team believed that more than adequate capacity was developed, and that the GOM could have deployed personnel and equipment rapidly and could have controlled any swarms north of the Atlas mountains.

Much of Morocco's improved capability to plan and execute a control strategy may be attributed to the national organization that was developed-- a structure which may be described as functional, comprehensive and well-adapted to Moroccan conditions. It was also characterized by a high degree of cooperation among the concerned governmental services and agencies. Morocco's strategy and tactics of control were, however, more a result of professional crisis management rather than a result of a long-term plan of prevention and control. The success of future monitoring and control efforts will depend not only on Morocco's internal level of preparation, but also on their success at working with neighboring countries on the development of collaborative detection and control strategies.

3) **Improved efficiency of operations such as survey, treatment and communications:**

Based on the above, the team felt that the GOM's capacity for survey, treatment and communications increased dramatically as the campaigns progressed, and that the GOM would be well-positioned to undertake a similar campaign in the near future. Future campaigns should, however, make more use of control methods such as the "Barrier Strips" technique for hopper treatments, as well as ground treatment in general which was not used as extensively as it could have been due to apparent mixing and formulation problems associated with the USAID-supplied pesticide, carbaryl. The team also questioned the use of the pesticide DDVP by the GOM, and recognized USAID's strong objections to its use as an important, albeit largely ignored, technical input. Finally, in light of the greatly diminished DL threat, the team questioned the validity of maintaining, for the sole use of future DL campaigns, important vehicle, equipment and material stocks. The team felt that these inventories could be used for other, more immediate needs within the agricultural sector.

4) **Improved GOM capacity for the management and monitoring of environmental, safety and health aspects of control operations:**

In the area of human safety, USAID made a significant contribution through the provision of protective clothing, cholinesterase test kits, and training in cholinesterase testing. These contributions, combined with the excellent health care and safety education system established in Morocco, resulted in a reduction in the number of treated persons for symptoms of organophosphate poisoning from over 400 persons during the first campaign to 23 cases during the second campaign.

In terms of monitoring the environmental impact of the locust control operations, the USAID-commissioned study by the Denver Wildlife Research Center, incomplete at the time of the evaluation, promised to be a very important contribution to elucidating the effects of organophosphate insecticides on ecosystems in arid environments.

Other Areas of Concern:

In addition to the above, the following summarizes other important areas also addressed by this report:

Pesticide Management and Disposal: Pesticide surplus disposal is a serious problem in Morocco and there exists a strong political desire to find a solution. The disposal problem is related to two types of pesticides: those which can no longer be used (i.e.: BHC) and where destruction is the only solution; and those which have uses other than locust control. Options for dealing with these pesticides are presented in detail in later sections. The GOM is making great efforts in this area and has proposed two new projects to be financed from national funds. Nonetheless, a great deal of work remains to be done and, given USAID's experience in the area, the team proposed that the Agency assist the GOM in further articulating its strategies.

USAID Responsiveness: Moroccan officials generally had a very positive view of USAID's contribution and the Agency's overall responsiveness to their requests. In all meetings, Moroccan officials expressed their gratitude to USAID for its contribution, specifically referring to the Agency's role in providing commodities and treatment aircraft, its leadership in environmental and health safety, and its assistance in organizational and human resource development. Reservations were, however, expressed with regard to pesticide selection (i.e.: the agency's refusal to supply or support the use of DDVP), as well as uncertainty with respect to AID's commitment to future activities such as pesticide storage and disposal.

Regional Cooperation: Learning from the latest locust invasions, Morocco has activated cooperation with neighboring countries. Presently, Moroccan teams are participating with Mauritanian counterparts in surveying locust breeding zones in northern Mauritania through the Maghrebian Intervention Force (FMI). Also, Moroccan officials expressed their interest in participating in the FAO Inter-Regional Preventive Control Project which was in the stage of preparation at the time of the evaluation.

Economic Assumptions: A brief discussion of some economic analysis indicated the use of different figures for locusts control cost per ha. by the FAO, USAID and the GOM. While Morocco used the overall figure of $15.36 after the 1988 campaign, it was reduced to $10.00 after completion of control operations in 1989. Morocco considers in the calculation the depreciation value of non expendable items over time and the personnel travel costs, but it does not include salaries and benefits. Accurate per ha. cost of the locust control campaign is very difficult to calculate,

though the team did provide a "ball park" estimate of between $19 and $20 per ha.

Principle Recommendations:

Of the many recommendations regarding the MLCP which are presented in detail in this report, the following are especially noteworthy:

- As there is no current DL threat, and in order to free-up resources which were diverted to the locust control effort back to their more traditional uses, the NLCC should be returned to the administrative oversight of MARA. The technical capacities of the NLCC could be better utilized for training and research under the direction MARA, and the Center's important vehicle, equipment and material stocks could be directed to more immediate needs within the agricultural sector.

- Prior to undertaking similar DL control programs in other nations, USAID should examine the feasibility of applying the institutional structure developed in Morocco as a model for other locust control operations.

- Given the severity of the pesticide storage and disposal problem in Morocco, it is highly recommended that USAID encourage and assist the GOM in establishing a panel of representatives from concerned national and international institutions to develop a long-term, national pesticide management plan. Specific pesticide management options are presented in later sections, but will require a great deal more analysis than could be accomplished within the scope of this evaluation.

- In order to further assist the GOM in developing a sustained capacity to monitor and control desert locusts, USAID should encourage GOM to organize periodic workshops and training exercises to assure the transfer of experience from trained personnel to new recruits. Specific areas to which USAID may itself provide training are outlined in the relevant sections, but include pesticide management and environmental monitoring.

- USAID should assure the continued availability of key items such as Greenness maps and cholinesterase kits for use in current monitoring programs and future control efforts.

- Climate-specific protective gears for pesticide handlers should be developed, perhaps through FAO programs such as the Inter-Regional Preventive Control Project.

- Given Morocco's experience and capabilities, consideration should be given to establishing a regional locust control training center in Morocco, specialized in the locust/grasshopper domain, which could serve both national locust control personnel, as well as those from neighboring countries.

Lessons Learned:

Important lessons learned that were deducted from the teams analyses and findings include:

- The successful monitoring and control of desert locusts requires a regional approach and cooperation amongst all concerned countries, and efforts to increase such cooperation should be strongly encouraged.

- The national organization that was developed specifically for locust control proved functional, provided for a comprehensive response to the problem, and could serve as a model to similar programs.

- With regard to the procurement of pesticides for similar programs, and given both the potential harmful impact of unused pesticide stocks, as well as the cost of their storage and disposal, quantities should be ordered on an "as-needed" basis to the extent possible, and the procurement of surplus or emergency stocks should be avoided. Furthermore, a detailed pesticide management plan must be a part of any future projects in which pesticides are provided.

- Although spraying with large aircraft is sometimes considered as posing to great a risk to the environment and human health, given their much larger treatment capacity, their use in large, unpopulated and non-agricultural areas is effective and should be considered for future operations.

- The provision of cholinesterase kits is a cost effective way for significantly improving the safety of the spray operations, as well as improving individual appreciation for health and environmental concerns. Such kits, and the provision of training to assure their appropriate use, should become integral components of future DL control programs.

CHAPTER I. THE USAID/MOROCCO LOCUST CONTROL PROJECT

1.1. Background

In July 1986, Desert Locust infestations were reported on 3,000 km2 on the Red Sea coast of northern Ethiopia and air traffic at the Asmara airport was brought to a stand still. Both aerial and ground spraying was undertaken, but it was known to be not entirely effective and that there were escapes. The Desert Locust Control Organization for Eastern Africa (DLCO-EA) reported that migrations from the coast to the winter breeding area of the western low lands adjacent to the Sudanese border had taken place. Near the end of August, fifth instar Desert Locusts (hoppers) were reported marching out of northern Ethiopia into Sudan, and on September 1st, a medium density population was observed 5 km. west of Kassala in Sudan.* Control efforts could not be mounted successfully due to hostilities within the border area. Swarms were also reported in Saudi-Arabia, and by mid-June had penetrated to northern and western Sudan. The succession of events thereafter becomes somewhat murky. It is sufficient to say that the upsurge began on the red sea coast and spread westward.

While the upsurge was occurring in Eastern Africa in 1986 a corresponding increase in Desert Locust populations was also recorded in West Africa but on a much smaller scale. Scouts in Mauritania reported a higher than normal solitary Desert Locust population in southern Mauritania, and Algeria sent-out spray aircraft, but failed to detect any sprayable targets. Since all available Mauritania crop protection personnel were engaged in grasshopper control in 1986-87, no surveys were conducted in northern Mauritania and Greenness (satellite imagery) maps were not yet available for that area. It is now known that a very large area of northern Mauritania possessed green, succulent vegetation, an ideal location for many swarms migrating from East Africa to breed and reproduce in exceptionally large numbers.

By the fall of 1987, progeny of the Red Sea locust population had spread west across the northern Sahel and southern Sahara and then northwest to Algeria, northern Mauritania and Morocco. Many experts concluded at this time that the infestation was sufficiently widespread and intense to constitute a plague.

Morocco was invaded on the 17th of October, 1987-- the first swarms arriving in the eastern portions of the country (Errachidia and Bouarfa) after having traversed the Sahara across Algeria. As the year progressed, the invasion occurred further to the west, traversing the Sahara across Mauritania and the Western Sahara. A total of 42 swarms were detected in 1987.

1.2. Project History

Faced with a Desert Locust (DL) invasion in Morocco in October 1987 which was threatening agricultural production of the country, and in light of the inability of Moroccan capabilities to deal with a DL invasion of potential plague proportions, the Government of Morocco (GOM) approached the international community for

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* Gaudet & Shaefers, September 1986.

assistance. Accordingly, GOM presented an initial request for emergency assistance to USAID/Morocco on November 4, 1987, which prompted a positive response from the AID Office of Foreign Disaster Assistance (OFDA) in Washington. A total of $446,686 in AID financing was made available for aircraft, pesticides and technical assistance. Based on a prediction of another serious infestation in the fall of 1988, USAID/Morocco established a longer-term mechanism for assistance-- the "Locust Control Project"-- for which a Project Identification Document (PID) was submitted to AID/W, and approved on February 9, 1988.

In the spring of 1988, Morocco was unexpectedly infested again by larger DL swarms of plague proportion. The GOM therefore presented a 2nd request for emergency assistance to USAID on March 10, 1988. OFDA again responded favorably by funding operational assistance in the amount of $1,835,840. This assistance included the procurement of about 300,000 liters of insecticide, flying hours of 2 Turbo Thrush aircraft for pesticide application, and technical assistance.

Considering the two consecutive invasions, the USAID/Morocco Locust Control Project (MLCP) was approved on May 11, 1988. Its initial duration was for two and half years, and a total of $3,500,000 in AID financing was made available. The procurement of inputs began immediately after approval to assist GOM in preparing for the predicted invasion in the fall of 1988.

By the fall of 1988, AID support of the Morocco locust campaign thus came from two sources: the OFDA emergency funding, and the budget of MLCP. OFDA financed part of the aerial spraying by DC 7s and the technical assistance of a spray specialist, for a total of US $307,500. Disbursements under the MLCP continued through the life of the project for the total available amount of $3,500,000.

Following a Mission review of the MLCP held on Dec 22, 1988, it was decided to amend the project, increasing AID's financial commitment by $20,000,000 (from $3,500,000 to $23,500,000) and extending the Project Activity Completion Date to June 1991. This decision was based on the expectation that a serious threat would continue through January 1989, if adequate rainfall occurred in southern Morocco and northwestern Mauritania. Though another invasion did not occur, due to the hiatus of USAID activities in Morocco during the Gulf War, the Project Activity Completion Date was again extended to June 1992 in order to ensure the adequate close-out of activities.

After approval of the Project amendment, few locusts were reported and control operations were halted on March 5, 1989. However, from available financing, $2,211,403 was spent from spring 1989 to spring 1992 for the demobilization of aircraft, the purchase of greenness maps, environmental monitoring studies and the procurement of certain commodities. Total U.S. expenditures for the Morocco locust control campaign from November 1987 to spring 1992 were $8.3 million. Of that amount, $2.6 million was from OFDA and $5.7 million was from MLCP.

1.3. Project Description

1.3.1. Project Goal and Purpose

Within the above administrative framework, and as specified in Project Paper dated May 1988 and the Project's Amendment No. 1 dated December 1988, the stated

goal of the USAID Morocco Locust Control Project was "to protect Moroccan agricultural and livestock production from the locust plague in ways consistent with protecting the health and well-being of the people and the environment." The more specific project purpose was to assist the GOM, in coordination with other donors, to control the Desert Locust invasion.

1.3.2. Project Inputs

To achieve the above, USAID programmed the provision of the following inputs:

Item	U.S. Dollar Value
Aircraft flying hours	4,753,450
Pesticides	4,848,932
Spraying Systems	312,500
Miscellaneous Commodities	177,500
Environmental Health and Safety Commod.	392,000
Logistical Commodities	539,000
Training and Technical Assistance	927,500
Audit	0
Contingencies	1,549,118
Total =	13,500,000

In more programmatic terms, USAID's inputs included:

a. Aircraft and insecticides to augment GOM treatment capacity. For the same purpose the project provided, in conjunction with training specific spray system to be adapted to the Moroccan helicopters.

b. Short-term technical assistance and selected commodities to improve the strategic and tactical planning of treatment operations.

c. Greenness (satellite image) maps which were provided and jointly studied by USAID/Morocco and the GOM. The maps assisted GOM in monitoring vegetative conditions favorable as DL breeding areas, and in defining areas requiring intensive ground surveillance.

d. Selected commodities designed to improve insecticide handling, communication capacity and survey methods.

e. Short term technical assistance, training and the necessary tools (cholinesterase test kits) to monitor the human health and safety concerns. The project also provided, through an American research center, training sessions for Moroccan scientists and an environmental impact study on the effects of the main organophosphorus pesticides used.

f. Finally, the project intended, if the locust invasion would had continued, to provide for the 1990 and 1991 campaigns any required short term technical assistance, training and commodities. To this

end, a further obligation of $10,000,000 was also foreseen-- the exact breakdown of which would be determined following an assessment of the success of the first stages of the DL control effort.

Although the above inputs were foreseen, following the effective end of the DL threat, USAID's assistance fell far short of that anticipated. The complete listing of inputs foreseen and those actually provided is presented in detail in Annex E.

1.3.3. Project Outputs

Emanating from the above, the project's intended outputs included:

1) Enhanced GOM capacity to control the Desert Locust invasion through aerial spraying using appropriate aircraft and pesticides;

2) Improved strategic planning and tactics of control operations;

3) Improved efficiency of operations that included survey, treatment and communications; and

4) Improved GOM capacity for the management and monitoring of environmental, safety and health aspects of control operations.

1.5. Evaluation Objectives

In fulfillment of MLCP requirements, this "end of project evaluation" was organized. In reference to the above-stated outputs of the project, the global objectives of the mission were to assess: (1) USAID's response to the GOM's call for emergency assistance; (2) overall project achievements; and (3) lessons learned. Specifically, the evaluation examined: (1) the effectiveness of the Project in meeting the output-level objectives; (2) the Project's progress in meeting the purpose level objectives; (3) the effectiveness of the Project in meeting its goal-level objectives; and (4) "spin off" activities. Other concerns and issues that were addressed were Project: (1) relevance; (2) effectiveness; (3) efficiency; (4) impact; and (5) sustainability. The complete Scope-of-Work to the evaluation is included in Annex A.

1.6. Evaluation Methodology

In accordance with the established plan, the team conducted the evaluation from late February to mid-March 1992. The evaluation methodology was designed to evaluate the Morocco locust control program as a whole and, specifically, the assistance provided by USAID. Moreover, cognizant of the evaluation's importance to future efforts, the team was careful to not consider the evaluation as only the appraisal of a completed effort, but also as a tool for learning-- from which similar campaigns for the control Desert Locust may be better prepared and executed.

Keeping the above in mind, the methodology consisted of the review of pertinent documentation, interviews with involved parties, and field visits to project sites. Documentation included that from technical and administrative sections

of USAID's Washington and Rabat offices, the AID Office of Foreign Disaster Assistance, the Office of Technical Assessment of the U.S. Congress, various agencies of the Government of Morocco, and contractors involved in the project. A complete listing of documents reviewed by team members is included in Annex G.

Interviews began with the team's initial two-day visit to Washington, DC, during which time members met with representatives from AID/W, OFDA, USEPA, and contributors to the OTA report entitled "A Plague of Locusts." The team then travelled to Morocco, and for the next three weeks conducted interviews with representatives from: USAID/Morocco, National Locust Control Center (NLCC), Central Command Post (PCC), Gendarmerie Royale (GR), Direction de la Protection des Végétaux (DPV), Ministry of Interior, Ministry of Transport, Ministry of Health, Official Laboratory for Analyses and Chemical Research, and FAO. Unfortunately, some Moroccan resource persons who participated in the field operations during the control campaigns were outside the country for training at the time of the team's visit.

The evaluation also included field trips to Ait Melloul, Tiznit, Taroudant, Guelmim, Sidi Ifni, Tata and Ouarzazate for the purpose of conducting interviews, visiting project-assisted facilities, examining pesticide storage locations, and observing the topography of areas where control operations took place. A complete listing of persons contacted by the team, as well as the team's itinerary are included in Annexes B and C, respectively.

CHAPTER II. ORGANIZATIONAL STRUCTURE

2.1.1. The National Organization for Locust Control

The government of Morocco responded rapidly to the initial invasion of locusts in 1987, and declared a national emergency. Within the framework of this declaration, a national organizational structure, consisting of several independent governmental agencies was established under a central directorate (see Annex D - organizational charts). Represented within this structure were the Ministry of Agriculture and Agrarian Reform, the Ministry of Interior, the Ministry of Transport, the Ministry of National Defense and the Ministry of Public Health. The reason for involving these ministries was due to the simple fact that no single ministry or agency was capable of managing the locust control effort alone.

2.1.2. Principle Actors

In practice, the major portion of locust control efforts relied on three actors, namely the Royal Gendarmerie (GR), the MARA and the Ministry of Interior. Their roles were complementary and may be summarized as follows:

- The Gendarmerie Royale (GR): assumed management of operations, the control of logistic support, as well as much of the administrative burden. In effect, the GR in collaboration with the army (FAR) had the necessary organizational and response capability to oversee the immense logistical requirements of the locust control operations.

- The Ministry of Interior (MOI): Through the Civil Protection Division in particular, the MOI was responsible for overseeing financial and organizational aspects of the locust control effort. Such responsibilities were consistent with the general mandate of the MOI which generally assumes the role of coordinator in the case of all national disasters.

- The Ministry of Agriculture and Agrarian Reform (MARA): Through the Crop Protection Division in particular, the MARA assured the provision of all technical support required to implement a sound locust control strategy.

2.1.3. The National Locust Control Center

In addition to the above, it is important to note the critical function played by the National Locust Control Center (NLCC). Traditionally placed under the administration of MARA and located at Ait Melloul, the NLCC has been a focal point for locust control activities in Morocco since 1975. Principle activities of the Center include: ongoing surveillance; the control, maintenance and distribution of inventories; the training of technicians; and the coordination of treatment programs. In fulfilling its role, the Center maintains several prospection/treatment teams composed of trained personnel, some ground equipment, an important quantity of pesticides and, as required, the annual rental of 3 to 5 aircraft for approximately three months for prospection and treatment. It has

storage facilities for equipment and materials, maintenance facilities for vehicles and application equipment, and pesticide storage and dilution capabilities. It also maintains regular communications with the FAO to monitor DL infestations in neighboring countries.

Since its creation in 1975 and until November 1987, the NLCC was under the administrative authority of the Crop Protection Service of (DPV) of MARA. When the locust invasion began in 1987, and along with the declaration of a national emergency, the NLCC was placed under the administrative jurisdiction of the Ministry of Interior. This facilitated many logistical aspects of the locust control program, including the oversight of customs clearance procedures, the canceling of landing fees for program aircraft, the movement of supplies through multiple taxing units, etc. Despite the end of locust invasion, the NLCC remained under the authority of the Ministry of Interior at the time of the evaluation. This is further discussed below.

2.2.1. Field Operational Components

Within the above framework of interagency collaboration, an operational structure specific to the locust control program was developed. This operational structure had four main levels of authority, consisting of:

Central Command Post (PCC): Situated in Rabat, the PCC assumed overall responsibility for implementing all locust control activities in the country, as well as coordinating all actions undertaken by the Regional Command Posts. The PCC was headed by a National Coordinator, appointed by His Majesty the King, who also served as the Commanding General of the Royal Gendarmerie.

Regional Command Posts (PCRs): Situated in the main cities of different provinces and under the PCC's general direction, PCRs were responsible for the establishment of survey and treatment (ground and aerial) programs specific to needs of their assigned region. Each PCR was headed by a Regional Coordinator, namely the Governor of the province, who was responsible for all administrative and financial matters. The Regional Coordinator was further supported by a designated agent from MARA who was responsible for all of the PCR's operational decisions, and a GR officer who facilitated execution. Representatives of different ministries were also assigned to each PCR, and acted under the authority of the MARA agent. Although equipped and organized to operate autonomously, PCRs depended upon the PCC for the approval of all decisions relative to control strategies, as well as for reinforcements whenever an infestation exceeded a particular PCR's capabilities.

Five (5) PCRs were initially established during the 1st campaign in the fall of 1987, and the number was increased to 12 in 1988 in response to more general locust invasion. PCRs were situated at Oujda, Bouarfa, Errachidia, Ouarzazate, Tata, Guelmim, Laayoune, Dakhla, Ait Melloul, Missour, Khenifra and Marrakesh.

Sub-Command Post (SPC): Every PCR had 2-3 SPCs which were responsible for surveying, ground treatment and, on occasion aerial treatments. There

were a total of 29 SPCs which reported to their corresponding PCR.

Operational Units (UO): There were 121 operational units in total under the control of SPCs. Every UO was responsible, within a defined territorial area, to undertake survey and limited ground treatment.

2.3.1. General Remarks on the Organizational Structure

As developed above, the organizational structure for the locust control program was comprehensive both in terms of agencies involved and in terms of geographic coverage. Though operationally the program remained under a single National Coordinator (Commanding General of the Gendarmerie Royal), its design also assured heavy involvement and oversight by MARA and MOI, providing for a well-organized array of technical capabilities and flexibility which was unique among locust control programs in the African region. Based on the team's interviews and visits, there was also a clear sense of collaboration and cohesion among the various members of the PCC in Rabat, effective coordination between participating agencies, and good vertical communication between the PCC and PCRs.

Though in strategic terms the operation was highly centralized at the PCC level-- i.e., the PCRs had to transmit all information to PCC in Rabat before taking action-- the PCC generally responded rapidly to the PCRs, reducing administrative delays and making for a well-coordinated national strategy. Moreover, in operational terms, PCRs were still able to make operational decisions within and according to the conditions of their specific localities.

In sum, and comparing the locust control organizational structure in Morocco to those of other countries in the region, the team was most impressed. For all intents and purposes, it appeared comprehensive, well-coordinated and quite disciplined (i.e. there were no deviations from policy, and there was respect of the hierarchy and roles of contributing parties). Much of this may be owing to the disciplined leadership provided by the Gendarmerie Royale. As other countries involved in DL control campaigns may not have such an existing structure from which to build, the applicability of this organizational structure on a regional level may not be practical. Nonetheless, it appeared to work quite well in Morocco.

2.3.2. Sustainability of the Program

Although the DL threat has been officially over for 3 years, the National Organization remains in reduced but functional operation-- the PCC continues to operate, the NLCC continues to be under the authority of the Ministry of Interior, and there are no plans to either disband the PCC or transfer the NLCC back to MARA. In addition to the organizational structure, locust control inventories at the NLCC are still being maintained for future invasions. In fact, about 95% of the equipment used during the locust campaign is presently stored in the center. This includes vehicles, sprayers, radio communications equipment and protective clothes. A maintenance schedule of vehicles and sprayers is planned for the purpose of assuring continued functioning of the equipment.

The principle reason for maintaining the status quo is the belief among Moroccan

officials that Desert Locusts can return again at any time, and that they should be fully prepared. This belief is further reinforced by a lack of preventive control of DL in the DL recession (or breeding) zones situated in neighboring West African countries. Another reason cited relates to the unresolved issues of the past campaigns, such as disposal of pesticides and environmental concerns.

The maintenance of the national organizational structure has clear advantages in terms of the sustainability of the program. Maintaining the PCC operational keeps the issue of locust surveillance and control at a high administrative level, and the treatment of important issues such as pesticide storage and disposal is not simply being deferred to the future. Briefly, if a DL invasion were to occur in the foreseeable future, Morocco would be well-prepared to launch a well-organized treatment campaign.

2.3.3. Recommendations

While the team greatly appreciated the level of preparedness described above, it did have some reservations about the wisdom of preserving personnel and large material and equipment inventories for the sole purpose of locust control. This is especially in light of the fact that, based on surveillance in neighboring countries via the FMI (see section on regional cooperation), there is no indication at the present time of any DL gregarious phase development in recession zones and, hence, little likelihood that an invasion will occur within the foreseeable future.

Given the lack of a well-defined threat, the team recommends that the GOM strongly consider certain actions which would return resources which were diverted to the locust control effort back to their more traditional uses. Although it does not appear to be an issue at present, one of these actions is the return of NLCC to the MARA. The team strongly felt that technical capacities of the NLCC could be better utilized for training and research under the direction MARA, and that the Center's important vehicle, equipment and material stocks should be directed to more immediate needs within the agricultural sector. A side benefit may be at the level of foreign assistance which may flow more freely to the Center if same were under MARA, and not designated solely for responding to a disaster which is not identified as such within the international funding community. Finally, given the PCC's ability to identify and respond to potential crises, the team felt that in the case a threat does develop, the GOM could quickly bring the NLCC back under the MOI, as was the case in the fall of 1987.

CHAPTER III. SURVEY AND CONTROL STRATEGIES

3.1. Introduction

During the past 45 years the world has witnessed four Desert Locust plagues. A similar pattern of upsurge and decline can be traced back to the dawn of history. During these 45 years new survey and control techniques have been devised and a vast reservoir of knowledge has been developed as to pest biology, food preferences, primary breeding sites and principal migration routes. Since the composition of swarms can vary widely, strategies must be used which take advantage of situations in which swarms are most likely to be concentrated.

3.2. Patterns of Invasion

Map No. 1 on the following page shows the migration routes taken in 1987 by the Desert Locust en route to the winter breeding area of north western Africa. Not shown is the apparent extensive movement into northern Mauritania from where a majority of the swarms that invaded Morocco developed in the spring of 1988. The fall 1988 swarm movement into Morocco followed basically the same routing as shown in Map No. 1, while those entering Morocco in early 1989 came almost entirely along the coast.

3.2.1. Strategies

The initial project paper "the Morocco Locust Control Project" signed on 5/11/88 in its annex entitled "Technical Analysis", described in general terms the strategic approaches taken by Morocco based on the biology of the pests and the effects of weather. As the project paper did not explain in detail the reasons for Morocco adopting these strategies, nor evaluate their efficiencies, the following paragraphs on control and survey strategies will attempt to do so.

3.2.2. Control Strategies

Locust swarms are generally brought into and remain within areas of low level wind convergence such as the Souss Valley of Morocco which, because of the low temperatures over the mountains, prevent them from continuing their migration*. Thus, Morocco is highly vulnerable whenever a locust upsurge occurs. Morocco's control strategy on the west was, therefore, to prevent locusts from crossing the Anti-Atlas Mountains and entering the agriculturally rich Souss and Massa valleys. To the east the strategy called for preventing swarms from crossing the High and Middle Atlas and entering the Morocco's north western agricultural zones. At the same time a major effort was made to prevent crop damage in the oases to the south.

Except for the Atlantic coastal area, the above strategy provided a zone of no more than about 200 kilometers wide in which to work. On warm days swarms easily fly 75-100 kms. So from time of detection to treatment of a swarm, even a few hours became crucial. As the numbers of swarms increased and compressed within

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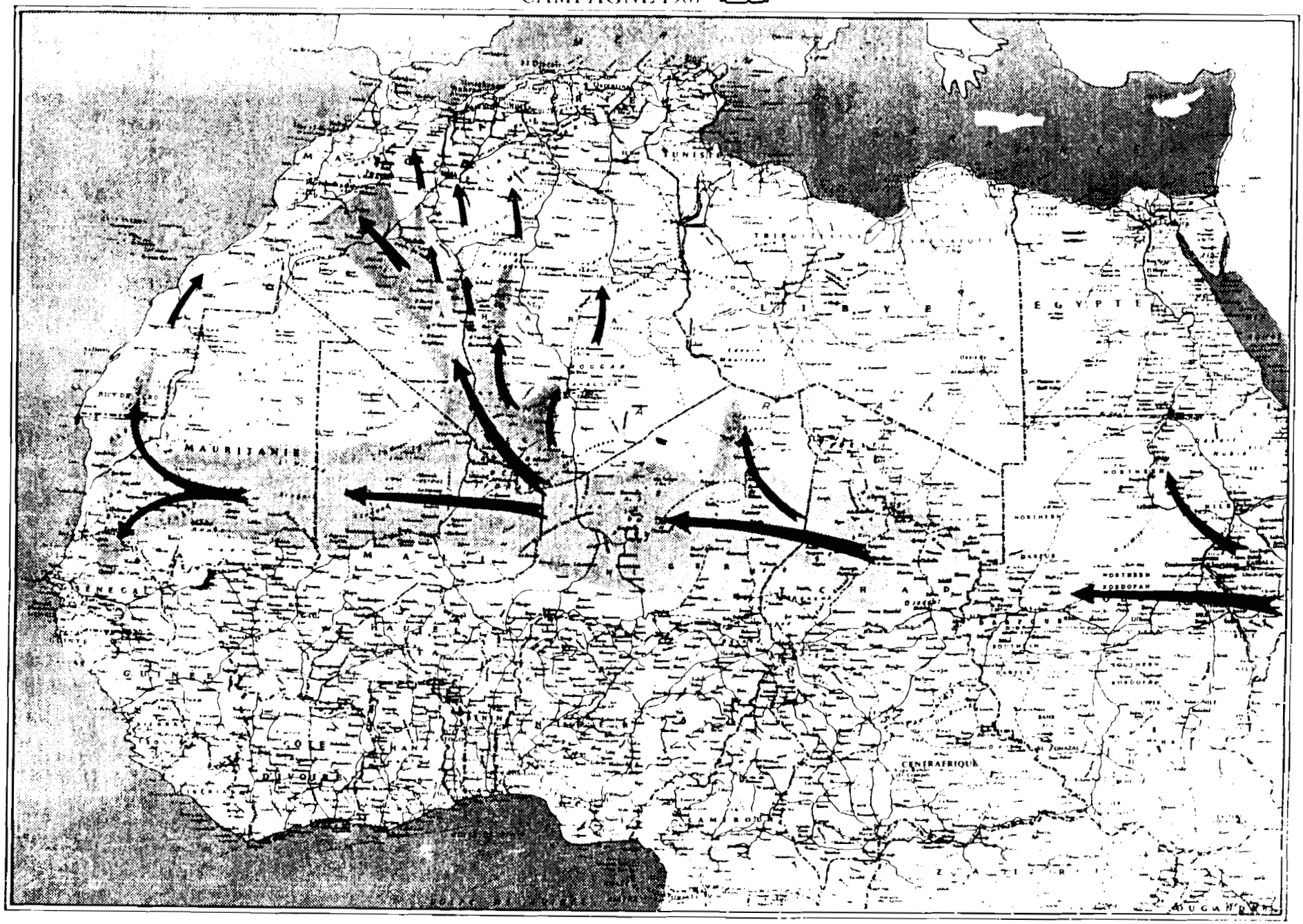
* Rainey, 1951

ZONE INFESTEE منطقة مجتاحة

CAMPAGNE 1987 حملة



relatively small areas, it was difficult if not impossible to identify and track individual swarms and, as they approached cropland, repeat spraying of some swarms occurred.

Swarms entering Morocco along the Atlantic coast offered more opportunity for preparation in advance of control. Though control was limited as the Moroccan Sahara was a military zone, the Moroccan Royal Army provided valuable information on swarms approaching control operations sites to the north. Morocco's basic plan called for 3 strategic lines of defense. The first two of these defense lines were to the south of the High Atlas Mountains while the third was to the north. Since only a few scattered locusts ever managed to migrate to the north of the High Atlas, activation of this third line of defense was never considered necessary.

3.2.3. Effectiveness of the Control Strategy and Recommendations for the Future

The control strategy was successful in providing Morocco the protection to its valuable crop land that it desired, but is not a ready solution to the overall locust problem. It was, however, a strategy of crisis management rather than preventive control.

Given Morocco's special vulnerability (i.e.: areas of low level wind convergence in agriculturally rich areas such as the Souss valley), and for its own protection, it must reach out further afield in the future to assist other nations in preventive measures. In light of both Morocco's dependency on neighboring countries for prevention, as well as its own proven organizational and technical expertise in locust control, the team strongly recommends that Morocco pursue a collaborative relationship with other concerned countries, perhaps offering teams of its own technicians to work with their neighbors in detection and control. This would be of benefit to all concerned, and could prevent a repeat of the 1987-89 massive actions.

In sum, the technology is available to practice preventive control and maintain the Desert Locust within recession areas, thus keeping Morocco from ever again being faced with a locust plague. However, until congeniality exists between all nations affected by the Desert Locust, preventive control will probably never be fully successful and plagues will continue to occur.

3.3. Survey Strategies

Forecasting locust upsurge is, at best, a difficult undertaking. Accuracy depends on long range weather forecasts and surveys that may have been undertaken weeks or months in advance. Since Morocco is not a recession locust breeding and population build-up area, but rather an invasion area, it had to rely on data supplied from other sources to make decisions. Unfortunately, during the control campaigns this data was either sparse, of questionable accuracy, or completely lacking. So like its control strategy, the survey strategy became one of crisis application.

Ground surveys are the primary means for detecting swarms. Scouts positioned close to Morocco's southern border relied mainly on visual cues and word-of-mouth reports from the local populace for swarm detection. This strategy performed

well in the relatively narrow confines that Morocco had to work. However, as the swarms developed they became compressed (i.e.: the distance between them became increasingly less), and when there was a large number of swarms present on the same day, it became difficult for scouts on the ground to maintain a swarms identity for tracking its movement. Thus, once a swarm was detected or its position approximately determined, helicopters of the Gendarmerie Royale were utilized to assist scouts on the ground to track the swarm until it could be controlled.

Swarms that entered Morocco and escaped detection and control may either turn northwest to Algeria or breed and reproduce in the deep canyons of the Atlas Mountain ranges. The young larvae (hoppers) produced can only be detected visually from the ground. Scouts must rely to a large extent on reports from the local populace as to their stage of development, size of bands and their direction of movement. Since these reports are often highly inaccurate or grossly exaggerated, Moroccan scouts must evaluate each report individually and make judgements based on past experience. Given this, it is highly unlikely that any Morocco PCR was so efficient that all hopper bands were found and treated. The terrain in which it had to work precluded such efficiency.

Morocco's swarm detection and control strategies came into play once again when these hoppers reached adult stage and prepared for the long migrations south to the summer breeding belt. Though, at this stage they posed no immediate threat to Moroccan agriculture, controls were taken to protect their southern neighbors and eliminate populations that could produce progeny which might invade Morocco several months later. Although not without problems the survey and control strategies meshed together well and were rigidly adhered to as would be expected from an operation coordinated in large part by military units.

As concerns improvements in survey strategies, and as in the case of control strategies, increased regional cooperation will be critical. The issue of regional cooperation is discussed at further length in Chapter VII.

CHAPTER IV. OPERATION AND APPLICATION OF PESTICIDE

Ground and aerial application of pesticides are the methods of choice for reasserting control after a locust outbreak has occurred. This section details the operational aspects of applying these methods under the MLCP.

4.1. Operational Objectives

The principal objective of the GOM operational plan was and continues to be protection of crops in major agricultural regions such as the Souss valley and areas north of the Atlas mountains. During the 1987-1989 campaigns, aerial application was considered as the first line of defense for Morocco. The complimentary role of ground application should not, however, be underestimated as it was effective whenever aerial application was not possible.

During the three campaigns, Morocco treated in total about 4.8 million ha. using aerial and ground treatment against DL adults and hoppers. Ben Halima reported in September 1990 the total area treated in 5 phases, as follows:

First: October 27 to December 31 1987
Treated 201,953 hectares aimed mostly at immature adults

Second: January 1 to February 29, 1988
Treated 92,742 hectares aimed at immature swarms and hopper bands

Third: March 1, 1988 to April 19, 1988
Treated 1,088,740 hectares aimed at mature swarms

Fourth: April 20 to July 30 1988
Treated 1,442,598 hectares

Fifth: October 10, 1988 - March 5 1989
Treated 1,989,622 hectares of dense swarms and immature adults.

Of the total treated area, about 1.1 million ha. (or 23%) were treated by ground, and 3.7 million ha. (or 77%) were treated by air.

4.2. Aerial Applications

4.2.1. Equipment Used

There were many types of aircraft employed during the campaign. Selection was based on many parameters such as terrain, distance and size of infestation. Although at the time of the first infestation in the fall of 1987 the GOM started with a smaller number of aircraft - approximately 20, the final total was 56 aircraft (42 airplanes and 14 helicopters). Of this total GOM supplied 17 airplanes and 14 helicopters and various donor countries supplied the rest, including: Piper Pawnees, Grumman Ag Cats, Cessna Ag Wagons and Douglas DC6.

Since different types of aircraft were supplied by donors, each type needed to be assigned to the type of terrain and distance that it could handle best. Aircraft with sufficient power and high maneuverability such as Turbo Thrush and helicopters were required for much of the rugged terrain and valleys, whereas the large planes, such as the DC 7s and C 130s, were principally used over large non-agricultural open or rolling flat lands. Based on collected information, it appeared that aircraft were properly assigned.

As concerns USAID's contributions, the Agency provided the flying hours of two Turbo Thrushes, two DC7s and one C130, as well as 10 spray systems for use with the GOM's Bell-205 helicopters. USAID's two Turbo Thrushes were the first donor-provided planes to arrive and become operational, making their first spray loads on November 10, 1987. Both the aircraft, as well as the U.S. pilots assigned to the program received high marks from GOM officials. As concerns the medium-sized aircraft in particular, they played a key role from the beginning, providing a unique and needed capability in terms of their range to targets, hectares sprayed per sortie, and compatibility with terrain and swarm size.

The following provides data regarding the contribution of USAID aircraft to the locust control program.

Table 5.2. USAID Aircraft During the Campaign, 1988-89*

Aircraft	Area Treated (Ha.)	Flying Hours	Consumption Kerosene	Fuel
2 Thrush	168,805	282H 19	57,120	
1 C-130	33,765	10H 30	33,643	
2 DC-7	314,180	160H 33		317,501
TOTAL	516,750	453H 22	90,763	317,501

With regard to large airplanes such as the DC7, their use is often discouraged due to their wide swath and, consequently, increased threat to the environment. Their long-range capability however, as well as their ability to spray up to 10 times the hectarage of even the medium-size Turbo Thrush (and with less people involved), offered clear advantages to the Moroccan locust control program. This became apparent when dealing with locust swarms that initially invaded non-agriculture zones south of the Atlas mountains. These swarms were extremely mobile, had infested very large areas, and within a very limited timeframe would move to the agriculture areas. It was only through the addition of the large airplanes that it was possible to reach and treat these large swarms in time. In addition, the navigation systems that were available on the larger aircraft allowed for more accurate location of treatment areas and better spacing of application. Insofar as spraying by such aircraft was limited to non-populated areas, their future use in similar campaigns should be given consideration.

* Based on USAID Situation Reports.

4.2.2. Aerial Operation

In addition to the well-trained and disciplined aeronautic professionals of the armed services who contributed to the locust control effort, Morocco had a distinct advantage in having an established private aerial spray company and trained pilots in-country-- many of whom were experienced in spraying wheat, barley, citrus and addressing other pest problems. The private operator "Agricolair" operates 15 Piper Pawnees most of which were leased by GOM for locust control. Due to limited range and load capacity of these smaller aircraft, they were generally deployed to PCR's where they could treat areas closer to established airstrips.

Due to the fact that long flights were frequently required from airstrips to areas of infestation, the aircraft carrying capacity was an important parameter. The Ultra-Low-Volume (ULV) formulation of the USAID-supplied pesticides was especially useful. Along with the small droplet sprays, the ULV formulation provided an increase in aircraft efficiency through increasing the area which could be covered in a single flight. As well, there was no need to transport dilution material and mix formulations in the field. The drift spraying or extended swath was also useful in broad areas or areas where flight paths were difficult.

As a regular procedure, the pilots received an early morning briefing, their individual assignments and maps. On occasions when travelling long distances for treatment was required, aircraft left the base with one load then landed at a closer sub-base for the second or third load and fuel. Frequently, two loads per day were the limit.

4.2.3. Hopper Treatments

Despite treatment operations that took place against DL adults from the beginning of the invasion, reproduction took place in Morocco-- eggs were laid and first hopper hatching was reported during the second half of the month of December 1987. Although clearly undesirable, hopper bands in their early instars require less pesticide to kill. They migrate smaller distances and are always on the ground. They can be treated from the ground at any time of the day with little risk of insecticide being carried away by the wind.

Perhaps the most effective and environmentally acceptable method of control against hoppers, "Barrier Strips," was not, however, used. As the insects move in marching bands, strips of 200 to 300 meters wide are treated well in front of the hoppers and skips of 200 to 500 meters are left untreated depending upon the speed of migration. The USAID-provided pesticide for that treatment was the Carbaryl Seven 4-oil, but due to difficulties encountered in using the supplied formulation, this pesticide was not fully utilized during the campaigns and barrier strips were not applied. Instead, entire areas infested by hoppers (similar to adult swarms) were treated by malathion or fenitrothion using aerial and ground application. More data should be made available to the GOM for future application of the Barrier Strip method.

Hopper treatment began on December 23, 1987 and continued till March 1988, mainly in the saharan zone. During the spring/summer campaign of 1988, hopper treatment

was more generalized, and during the fall of 1988, no hopper treatment was undertaken. The total reported area treated on the national level was about 162,157 ha. during the fall of 1987-1988 (about 52% in Dakhla and 41% in Laayoune), and about 1,051,708 ha during the spring/summer of 1988 (about 30% in Guelmim, 23% in Tata, 17% in Bouarfa, 13% in Ouarzazate, 9% in Errachidia, 5% in Laayoune and 3% in Dakhla).

4.2.4. Swarm Treatments

Because treating swarms in flight expands the area to be treated and presents hazards to the aircraft and crew, all adult treatments were made on settled swarms on the ground and none on flying swarms. Settled swarms were treated early in the morning within a few hours after sunrise when they were still on the ground and before their movement out of the resting site later in the day. Normally, swarms occupying less than 100 hectares were treated by ground teams with truck or back pack sprayers. Swarms occupying 100 to 500 hectares were treated with small aircraft, and swarms covering 500 to 5000 hectares by medium size aircraft. Large aircraft were used for swarms occupying areas over 5000 ha.

4.2.5. General Remarks on Aerial Operations Capability

Given the expense of aircraft flight time, it is essential that each aspect of an aerial spraying activity be understood and the operation controlled so as to secure maximum productivity. During the course of the campaigns, and according to collected information*, there were many areas of improvement after the program started, especially in comparing the 1988 campaign with that of the fall of 1987. As personnel gained experience or took training, improvements were reported on all aspects of the operation, including: daily average of hectares treated; area treated per hour by type of aircraft; general logistic support; ground and air surveys; mapping; marking; and ground treatment.

As for the current Moroccan capability, technical officials estimated that the GOM is capable of treating around 20,000 to 30,000 ha. per day taking into consideration actual available aerial and ground treatment equipment in-country. An invasion beyond that capability would require renewed international assistance.

4.3. Ground Application

Ground treatment mainly used back pack powered sprayers, truck mounted mist blowers and Exhaust Nozzle Sprayers. For application, about 520 vehicles and 2600 sprayers were used along with 10 million liters of different pesticides and 4200 sets of safety kits (Ben Halima 1990). Due to problems associated with the formulation of the principle ground treatment pesticide provided by USAID (see next chapter), and an apparent misconception on the part of field technicians that the exhaust nozzle sprayers were outdated, it would appear that ground application may not have been exploited to the extent possible. Nonetheless, ground application was important contributor to the total application program. Published reports indicated that ground application accounted for about 35% of the total area treated during the fall of 1987 and spring/summer 1988, though

* Arifi, 1991.

much less in fall 1988 (only about 7% of the total area treated) during which time the control operation was responding to larger and denser swarms of highly mobile insects. The above results in a weighted average of about 23% of the total area being treated by ground during the three campaigns which is a respectable percentage given the total area treated. The PCR of Ouarzazate had recorded the highest area treated by ground during the first two campaigns, followed by Errachidia, Guelmim and Bouarfa.

4.4. Other Considerations

4.4.1. Ground Support

The ground support for the locust control operation involved mainly surveying and marking areas to be treated by aerial spraying. Most of these activities were carried out by 200 ground-based survey teams assigned full time to the locust program. These teams had responsibility for prospection and the identification and marking of swarms for aerial treatment. Survey teams were assigned to PCRs and provided with vehicles, radios, and marking equipment. As swarms were sighted and reported, the teams were dispatched to the area to determine size, density, biological activity and location coordinates. Flying swarms were tracked until they settled in the evening, and findings were communicated by radio, telephone or in-person to the PCR. The PCR then synthesized information from the different teams and transmitted same to the PCC in Rabat. Decisions were made prior to the following morning relative to what swarms would be treated, and by what available aircraft or ground equipment. The survey teams also recorded breeding locations and egg laying sites.

The PCC in Rabat continues to maintain a central information system which is equipped with telephone, telex, and radio networks to communicate with key locations throughout Morocco. A task force of Crops Protection and Gendarmerie Royal staff operates these communication lines, receiving information, updating and analyzing operations, and sending back new instructions and information to the field. A computer program was developed which tracks all aspects of control operations on a daily basis. Large strategic maps indicating cumulative sightings throughout Morocco are updated daily.

4.4.2. Marking and Spray Runs

Pilots have difficulty identifying swarms on the ground, and although swarms become visible as they begin flight (especially through the sun's reflection on their wings), such is not an ideal circumstance from which to undertake aerial pesticide application. Increased distance to a swarm exacerbates the identification of a targeted swarm, and long runs are difficult to ground mark consistently without multiple distraction to the flight crew. As mentioned previously, the large category aircraft in Morocco were better adapted for this work through being endowed with improved navigation equipment-- specifically, the Omega Navigation System modified with the 211 agricultural grid software to improve accuracy from 1.5 miles to 0.5 mile. Smaller planes relied on directional compasses for 180 degree back-and-forth runs coupled with markers on the ground. Ground survey teams in targeted areas worked with the pilots in burning tires for markers, using USAID-supplied flare bombs, or laying out bright fluorescent cloth with a large white arrow pointing toward the spray blocks. Moroccan technicians

indicated that the latter was the most efficient.

4.4.3. Communications

Radio communication is essential considering the size and distances of most locust operations. To assure efficiency of communications, transmission availability should be between the operations site and the aircraft; the operations site and the spray block; and the operations site and the command center. To this effort, USAID supplied 88 radios which, according to Moroccan communication technicians, were solid, practical and efficient. At the NLCC in Ait Melloul, there is a maintenance workshop which, at the time of the evaluation, appeared to be an efficient facility for radio repair and communications equipment storage. Nonetheless, information obtained indicated that, during the locusts control campaigns, many marker personnel in the spray block did not have communication with the aircraft due to lack of radios. Numbers of unequipped marker personnel and the precise reason for this important oversight are unknown, but it should be an item addressed before any future campaign is undertaken. At the time of the evaluation, it was further mentioned that there was a need for additional spare parts and different antennas for the AID donated equipment. As concerns the antenna, there is apparently an adjustable type that can be adapted for various distances. A lower frequency antenna with stronger mounts was requested.

4.4.4. Greenness Maps

The ability to monitor the distribution and growth of natural and agricultural vegetation in the Sahel is an integral part of locust control efforts, especially with regard to prediction and survey. This information was presented in the form of vegetation index or "greenness" maps for each two week period during the locust/grasshopper season. They were produced from satellite images by the EROS Data Center, U.S. Geological Survey, in Sioux Falls, South Dakota. Though such maps do not identify the location of where locusts are present, they were most useful to the GOM in determining vegetative conditions of specific areas, thus aiding in identifying those areas which may be favorable as breeding areas and which may require intensive ground surveillance.

USAID supplied these maps to GOM on a 10-day cycle during the campaign, and will continue to supply them under the Morocco Locust Control Project until only April 1992 due to end of project. However, because of the importance of these maps to both locust control and agricultural monitoring in general, the GOM expressed its interest in having USAID assure their continued supply after the completion of the MLCP. AID/M may have to consider that request using other forms of funding. Computer software having been set up at the AGRHYMET Center in Niamey, Niger, they are now made available in a two-day time frame.

4.4.5. Training

Although Morocco has one of the most efficient, best trained and equipped Crop Protection Services, it was small in comparison to the desert locust problem they faced. Though its personnel was supplemented in large measure through the use of military forces and personnel from other governmental agencies, the problem developed so rapidly that there was little time to train these additional forces,

other than "on-the-job," in the methods of large scale locust control.

Technical assistance in the form of operations training from various donors helped considerably in this crisis. FAO sponsored a course on pesticide application techniques (ground and aerial) at the National Desert Locust Control Center in Ait Melloul from October 11-20 1988 for 25 technicians. USAID provided a variety of training, including that related to the installation, use and maintenance of Simplex 10 spray systems for GOM Bell 205 (two-weeks duration). MARA also provided a locust control training course for 200 field agents. In many respects, therefore, the campaign became a learning as well as operational experience for Moroccan participants-- one which should serve well for future similar infestations.

4.5. Level of Preparedness and Degree of Improvement in Operational Capability

In effect, when potential locust plague conditions develop, there is not much time to mobilize the necessary equipment, manpower and supplies and arrangements should be made well in advance in order to have a functioning organization ready to act. To this end, all trucks, vehicles, equipment and pesticide stocks are being maintained and stored for future locust campaigns, and any use for other purposes requires the approval of PCC Rabat. From an operational standpoint, this is most desirable. In considering the amount of equipment and minimal extent of the current DL threat, however, the team did have reservations about maintaining this level of preparedness. This issue was more fully addressed in the above section on the locust control program's Organizational Structure.

As concerns the degree of improvement in operational capability, it may be noted that prior to the 1987 locust invasion the GOM only had the capacity to spray 2,000 hectares per day with the aircraft and ground sprayers available to them, and there was a severe shortage of trained technicians to undertake all of the required pesticide handling, prospection and spraying operations. As GOM and donor aircraft numbers increased, the total volume of work accomplished in a little over 16 months was 4,800,000 hectares sprayed, and at the present time, and with its own resources, the GOM has a capacity of treating 20,000 to 30,000 hectares per day. Such figures clearly suggest a significant improvement in the GOM's operational capability.

CHAPTER V. PESTICIDE MANAGEMENT AND HAZARDOUS WASTES

5.1. Pesticides Used under the MLCP

The selection of pesticides is based principally on effectiveness against the pest, environmental impact and health concerns. The following details the choice and use of pesticides under the MLCP

5.1.1. Pesticide Effectiveness

Mortality of locusts due to a particular pesticide is very difficult to determine for swarms. The number killed in the treatment area itself is basically a measure of the speed of knockdown of the pesticide, as opposed to the true effectiveness of the pesticide. As a treated swarm begins to move, often only one or two hours after treatment, and if the true pretreatment swarm density is unknown, which is almost always the case, the problem of measuring effectiveness is compounded. One method for measuring effectiveness is to collect treated locusts, hold them in clean cages with adequate untreated water and food, and perform mortality counts on a daily basis for at least four days (seven days in the case of carbaryl). This technique is, however, biased toward increased mortality unless untreated locusts can be maintained as a control.

In terms of effectiveness against locusts, and of those pesticides used in Morocco's locust control program, the following may be noted:

DDVP: This pesticide has a very rapid knockdown and, hence was preferred by the GOM. Following an application, large numbers of dead or moribund locusts are found in the DDVP treatment area. The large number of dead locusts is not a guarantee of extremely high mortality as the true pretreatment density is unknown and the subsequent mortality after flight begins is uncertain.

Malathion: This pesticide has a slower knockdown than DDVP resulting in fewer dead or moribund locusts in the treatment area. Some field observers believe that malathion treatment causes earlier flight of the swarm which reduces the number of dead left in the treatment area. Subsequent mortality during the flight of the swarm on the day of treatment and following days is extremely difficult to evaluate under campaign conditions. Some feel that the slower knockdown rate of malathion may lead to a second treatment of a treated swarm.

Carbaryl: This pesticide has an even slower knockdown rate than malathion with treated individuals surviving for several days during which a treated swarm could be retreated several times. For this reason, carbaryl is generally restricted to the treatment relatively slow-moving hoppers.

5.1.2. Pesticide Selection

The two pesticides directly purchased by USAID for use in Morocco were malathion and carbaryl. Malathion was in the ULV formulation (96% ai) and the carbaryl was

in the Sevin-4-Oil formulation (4lbs ai/gal). Both formulations are labeled by USEPA for grasshopper control on rangeland and certain other crops. The malathion was purchased from Cyanamid International Sales Corp., Cyanamid Plaza, Wayne, New Jersey and the carbaryl was purchased from Rhone-Poulenc Agro-Chemical, P.O. Box 125, Black Horse Lane, Monmonth, N.J.

DDVP was the chemical of choice of the GOM due to its rapid knock-down rate. However, because it was not registered for use on grasshoppers by USEPA, USAID/Rabat could not support its use. USAID/Rabat is to be complimented for the thorough and conscientious job of evaluating all aspects of the use of DDVP and providing this information to GOM. The volume of cables between USAID/Rabat and AID/W is an indication of USAID/Rabat's desire to provide the best scientific information to the GOM. Although USAID/Rabat could not persuade GOM to discontinue DDVP use, it clearly was not the fault of USAID/Rabat.

5.1.3. Pesticide Registration

The Bureau of Pesticides and Registration of the Crop Protection Service is responsible for pesticide registration in Morocco. The current system began in 1980 and is much more thorough than the previous system. A modification of the French system of hazard ratings for pesticides is used with "A" being both very toxic and toxic and "C" being less. Under this system, ULV malathion is in category "A", though according to the classification given by the USEPA (Category III of the toxicity scale) is less toxic. Malathion has an oral LD50 of 2800 mg/kg (male rat) and 1,000 mg/kg (female rat), whereas the dermal LD50 for rats is 4100 mg/kg.

5.2. Pesticide Handling

Planning for pesticide arrival in-country is difficult as the extremely large volumes (usually in 200 l barrels) can easily overwhelm the personnel and facilities available. This problem may be compounded by concurrent arrival of pesticides ordered by the country and donors. The following outlines the stages of pesticide handling under the MLCP.

5.2.1. Off-Loading

Avoiding drum damage is an essential beginning to sound pesticide management program. For although damaged barrels generally retain their integrity over a few months, beyond that their storage becomes problematic and their transport difficult, if not impossible.

The first step of drum damage generally occurs during the off loading process (air or sea deliveries). Though, generally speaking, off-loading for the Morocco desert locust campaign was handled in a reasonable manner, problems were encountered. Arrival of the drums at the primary staging area at Ait Melloul was a round-the-clock activity with a shortage or absence of forklifts or other mechanical assistance. Barrels were rolled off trucks and even with tires to cushion the fall, most, if not all, of the barrels received their first major damage. Forklifts and cranes should have been provided for all off-loading, and barrels should have been on pallets to facilitate handling.

The damage caused to barrels which contain unused pesticides presents a serious long-term problem. As these barrels continue to age (many more than three years old at the time of the evaluation), the potential for leaks becomes more likely, and their transport much more difficult. The situation presented by damaged barrels should be factored into the options presented on pesticide disposal which are outlined below.

5.2.2. Transport to Regional Facilities

Due to poor packing and, in some cases, road conditions, transport to the regional level and to the airstrips added additional damage to the barrels. Transport of pesticides from off-loading facilities to regional locust control facilities by tank trucks was attempted initially. The use of such trucks to transport pesticides to landing strips was a good idea and should be given consideration in future control, programs. Apparently lack of adequate cleaning of the tanks and design flaws (bolts through the tanks to the cradles) defeated this system. The bolts rusted or were eaten away by the chemical resulting in major leaks.

5.2.3. Transfer of Pesticide to Aircraft

The transfer from drums to aircraft was initially by heavy suction pipe which had to be lifted from one barrel to another. Workers tended to use both arms to lift the pesticide covered pipe, resulting in major contamination of their protective clothing and much leakage. The dry break connections provided by USAID/Rabat were a vast improvement. A simple, ingenious device, several barrels connected together with pipe was developed so that several barrels could be draining into the system at the same time and the accumulation pumped from an end barrel on a continuous basis. This system is also used for redrumming.

5.2.4. Barrel Draining and Destruction

The degree to which the barrels were drained is uncertain. During the height of the campaign, there was little time to thoroughly drain each barrel and triple rinsing presented a diluted waste that had to be contained or sprayed over a treatment area. The amount remaining in a 200 l barrel probably ranged from two to 10 l of pesticide if not rinsed, or rinseate if rinsed. The barrel crushing equipment provided by USAID/Rabat appeared adequate, though the question of burying the crushed drums or leaving them on the surface should be more thoroughly addressed and agreed upon with GOM. One appropriate procedure would be to treat drums with lime and then cover them under about two feet of soil.

The guidelines for knocking holes in the top, bottom and sides of each drum almost as soon as it is emptied is a sound approach. In this case of the MLCP, however, they do not appear to have been strictly followed. The compelling need of the GOM for barrels to transport their formulated DDVP, and the fact that other countries involved in the desert locust outbreak did not make substantial contributions of pesticides, made empty barrels from AID-provided pesticides an attractive commodity. In hindsight, the barrel destruction guidelines should have been as respected as the regulation that only EPA-approved pesticides be used in U.S. aircraft. Future programs should also make barrel destruction mandatory, but additional provisions for inspection services should be included

to assure regular compliance with regulations.

5.3. Pesticide Storage

5.3.1. Storage Facilities

Pesticide storage facilities in Morocco are better and more numerous than elsewhere in the Sahel, and the paved road network in Morocco affords it certain advantages over its neighbors in terms of stock consolidation. However, there are not enough covered, concrete floored storage facilities to handle the large amounts of pesticides which were stockpiled in anticipation of continuing locust invasions in 1989 and beyond. Care has been taken to separate the barrels of different pesticides and formulations. Aisles have been left to provide access for observation. Often three or more rows of barrels are end to end between aisles. Single rows between aisles are much to be preferred for careful observation of leaks. USAID has begun the process of procuring and supplying wooden pallets; however, these have not arrived at the most distant storage facilities. Pallets between the barrels and the cement floors or the ground are absolutely necessary, and pallets between each layer of barrels is highly recommended to improve early detection of leaks.

Temporary storage of pesticides in the open and in reasonably undamaged barrels for a few months probably should be tolerated in campaigns such as that undertaken in Morocco for locust control. However, the current situation characterized by long-term (up to 3 years) storage on the ground and in the open should be considered a crisis. Most of the barrels are too damaged to be moved and the quality of the contents is uncertain. Soil contamination is now proceeding at a rapidly escalating rate, and the potential for contaminating shallow water tables in urban areas such Ait Melloul poses a real threat.

As concerns other important items, all storage facilities appeared to have adequate security. There was, however, a lack of adequate, readily available water, soap and towels for emergency clean up, and importantly, no fire fighting equipment was observed. Most sites did have water wells in the storage area, though these should be carefully observed for signs of contamination.

5.3.2. Storage Capacity

Storage capacity is limited. That which does exist appears adequate in most cases and is a carry over from previous campaigns. Very old stocks of BHC dust and bait occupy much useable space. The forklifts and pallets ordered by USAID and better storage management practices will safely increase the volume which can be stored in existing facilities, and the GOM is planning for new modern pesticide facilities. Their efforts in this regard are to be complemented, with two projects in the process of approval. One is near Ait Melloul where a 4000 m^2 of storage shed is to be build for NLCC. The second project, which will cost about of 20 million DH, concerns building of a round-topped modern storage shed at each of 8 Regional Command Posts.

The real question is how much storage is reasonable, and the tendency to retain old stocks just because there is adequate, safe storage must be resisted. The vast stocks of BHC, for instance, primarily exist because there were storage

facilities. The options for pesticide disposal and destruction presented below should be further studied. As well, a warehouse management plan should be developed to rotate stocks, and continuing progress in consolidating stocks from PCRs should be made.

In practice and during the height of campaign it is very difficult to determine the "critical balance" between (1) the exact quantity of pesticides needed for an undetermined size of a locust invasion and (2) the desire to minimize the surplus stock to be disposed of at the end of the invasion. The best decision is probably made on the spot based on the best available information at the time and in consideration of the anticipated magnitude of the invasion. Nonetheless, in terms of future programs, and given current airlift capabilities, the need for large reserves of chemicals is questionable. The cost of air freight is relatively low in comparison to the costs of storage and the destruction of obsolete pesticides. Consequently, future pesticide requirements for large-scale programs should be filled in a more limited manner.

5.3.3. Pesticide Labeling

Another serious problem noticed was the labeling of pesticide drums. Paper labels fade and peel. U.S. malathion barrels have the label painted on the barrel but almost none of the barrels can be identified as to date of manufacture. This date should be painted on the barrel, preferably on both the side and top because of potential fading and scraping problems. USAID provided large plastic stick-on labels for products that were redrummed. The stick-on label provided space for the date of redrumming, but did not provide for the date of manufacture of the contents. These should be included as well.

5.4.1. Pesticide Stocks

Of the total of 540,000 l of malathion provided by USAID (through both OFDA and USAID/Rabat), 113,200 l remained in stock-- indicating that 426,800 l were used to treat 516,750 ha. at an estimated 0.83 l/ha (11.3 oz/a). This is in reasonable agreement with the 0.75 l/ha in the project proposal, and well within USEPA guidelines. It should be remembered that this agreement between volume used and ha. treated is based on conversion of volume to ha rather than a measurement of the actual surface treated which is practically impossible. The amount of USAID-purchased malathion used for ground application could not be determined but was probably nonexistent or very small since the motorized backpack mistblowers were calibrated for 5 l/ha. A small quantity could have been applied by Exhaust Nozzle Sprayers but it is not likely. Carbaryl apparently was not used because of mixing and formulation problems (i.e. its dissolution using diesel fuel was problematic). Much of that tried for use in Morocco may, in fact, have been from old, poorly maintained stocks, the consistency of which clogs application equipment.

5.4.2. Pesticide Disposal

An important problem of concern to all associated with Morocco's locust control program is the disposal of surplus pesticides. The Locust Control Center (NLCC) has provided inventory lists of pesticides from their computerized inventory. The inventory of stocks used in the 1987-1988 campaigns appears to be well

verified. The inventory of BHC stocks may, however, be out-dated and requires verification. The following tables present global inventory figures as of March 10, 1992. Further detail is presented in Annex F.

Table 5.4.1 Stocks of Locust Control Pesticides and Solvent in Morocco (March 1992).

Pesticide (all formulations)*	Total (in liters)
DDVP	1,489,905
Malathion**	472,800
Fenitrothion	514,230
Decis	135,205
Karate	125,650
Diazinon	2,795
Dalla	19,600
Solvent (HAN)	2,527,130

*See Annex F for specific formulations and storage locations
**Includes 113,200 l of USAID-provided ULV malathion

Table 5.4.2 Current BHC (HCH) stocks in Morocco. 1992.

Formulation	Total
BHC (HCH) 15% liquid	497,400 liters
BHC (HCH) 10% liquid	271,000 liters
BHC (HCH) 3% dust	711,030 kilograms
BHC (HCH) wheat bran bait	380,690 kilograms

*see Annex F for storage locations

No definitive, recommended surplus pesticide disposal procedures are agreed upon yet by EPA, OFDA and FAO. Available options are very expensive, present certain real or perceived hazards, and are not acceptable to all members of the world community. These options are further presented below.

5.4.3. Disposal of BHC

The most potentially hazardous of those pesticides in storage in Morocco is BHC, and there appears to be a consensus and a strong political desire to ensure that all BHC stocks are destroyed. Since BHC is essentially banned throughout the world, the only choice for disposal of BHC stocks is destruction (i.e.: through construction of a cement kiln, in-country incineration, or other means). The factors to be considered in evaluating the various methods (i.e.: costs, risks, etc.) are not, however, well understood. This was evidenced by the lack of any formulated policy or proposal issued from the GOM prior to or during this evaluation. Given this situation, it would appear that more information is required and that the subject should be openly discussed and debated. Given AID's experience in this area, it could play an important role in facilitating

the formulation of a BHC destruction plan.

5.4.4. Disposal of Other Pesticides:

The existing stocks of currently useable locust pesticides present the most controversy. These stocks are perceived by GOM as having a monetary value and, in the case of much of the DDVP, represent an investment of GOM funds. The problem is that these pesticides are rapidly nearing the end of their shelf life and may well not be the pesticides of choice during the next locust invasion. The disposal of surplus stocks of these other pesticides which have currently acceptable alternate uses presents certain options. These options are as follows:

Option 1:

The best disposal option is to use these pesticides for a currently accepted alternate use in Morocco. The need under this option appears limited, and more importantly, its applicability is rapidly expiring as these pesticides near the end of their shelf life.

Option 2:

A second option is to reformulate malathion into products that can be used in Morocco. Malathion is registered for use on sugarbeets, tree fruits, vegetable crops, ornamentals, olives and rape-seed, as well as for stored cereals, legumes and seed potatoes. Mixtures of malathion and dimethoate are registered for use on citrus, tree fruits and olives. (Crop Protection Service 1989). At least 8 companies sell formulated malathion in Morocco (SOTRACHIM, B.P. MAROC, SEPPIC-MAROC, FELLAH SOUSS, ESSO, BASFMAROC, PROMAGRI, AMAROC). Alternative uses for other surplus pesticides should be investigated.

Option 3:

The third option is to distribute these stocks to other countries which could use them in a short time. In almost all cases, repackaging would be required and would present an enormous empty drum disposal problem. An additional constraint may be a perceived monetary loss on the part of the GOM.

Option 4:

The most expensive option is destruction of existing stocks. This may be done through simple incineration, incineration using a cement kiln or other method. Because of the costs, as well as the remaining a great deal of debate regarding destruction methods (with some in fact suggesting that the waste be entombed until an appropriate method is discovered), this option must be considered if none of the other options can be used.

A principle area of concern to USAID, the Government of Morocco, and others involved in the locust control effort related to the potential harmful impact of the program on both human health and the environment. This chapter describes the steps taken by the project to avert or diminish the threats inherent in such an undertaking, and discusses the degree to which successful results were achieved.

6.1. Human Health

6.1.1. Protective Clothing

One of the major concerns for human health associated with the spray campaigns in 1987/88 and 1988/89 was the exposure of workers to the organophosphate (OP) insecticides used. Although USAID provided only malathion and some carbaryl (which was generally not used during the locust campaigns), the GOM utilized DDVP as their major insecticide because it has a much better knockdown effect than malathion or fenitrothion, which was provided by other donors.

All of the above insecticides are inhibitors of acetyl-cholinesterase (AChE), the enzyme that rapidly hydrolyzes the neurotransmitter acetylcholine in the synaptic junctions between nerve cells and between neurons and muscles. Inhibition of this important enzyme results in residual acetylcholine in the synaptic cleft, which in turn causes uncontrolled muscle contraction, convulsions, nausea, dizziness, and eventually death by paralysis of the breathing musculature. OP pesticides can be taken up by ingestion, inhalation, or skin penetration. It is therefore important to protect workers who handle OP insecticides against uptake by all of these routes.

While uptake by ingestion can be avoided by cleanliness - no smoking, eating or drinking in the vicinity of pesticides, and washing hands after handling OPs - only protective gear like coveralls, respirators, gloves, boots and goggles can provide effective protection against inhalation and skin exposure. USAID made an important contribution to worker safety by providing 2200 kits of protective clothing consisting of coveralls, gloves, boots, respirators and goggles. These were to be used by workers who were in direct contact with pesticides to prevent skin exposure and inhalation. The respirators were NIOSH-approved, 3M Easy-Air 7200 dual-cartridge respirators for which an ample supply (> 30,000) of 3M 7521 Organic Vapor cartridges was provided. During the team's field visit to Ait Melloul, a large number of cartridges were still stockpiled at the regional PC's warehouse. We were shown stocks of respirators and cartridges of various other donors that were also warehoused at the PC. Likewise, coveralls, boots, gloves and goggles were stored in quantity. This would indicate that sufficient protective gear should have been available during the campaigns.

Although protective gear was available, there appears to have been a problem with acceptance of some of this gear by the workers; particularly in warm weather the use of some of the suits, masks and goggles resulted in heat stress. To avoid similar problems in the future, Dr. Jaouad Mahjour of the Ministry of Health, who served as the chief medical officer at the Central Command Post at Rabat during

the campaigns, summarized his recommendations for protective gear as follows:

- Suits should be made of material that is resistant and impermeable to the products used; preferably light cotton suits should be provided to be worn under the impermeable outer suit to absorb perspiration;
- Masks should be lightweight with disposable filter cartridges;
- Gloves should be made of leather with attached sleeves; and
- Goggles should have lenses (perhaps made of glass) that are not made opaque by contact with the chemicals used.

The high-aromatic naphtha solvent of the insecticide formulations seems to have been incompatible with many of the plastic materials used in suits, gloves, goggles, and even tubing and gaskets in spray equipment. In the case of backpack sprayers, this resulted in ruptured hoses or leaking connections which often soaked the applicators with insecticide.

During the first campaign, 423 workers became ill and had to be treated or hospitalized. Therefore a comprehensive preventive health care system was organized in spring and summer of 1988 and which was in place when the second campaign began in fall of 1988. It involved the existing health care system at the provincial and local level, with 45 M.D.s and 130 trained nurses dedicated to the medical task force. Training courses were set up, using the WHO publication "Poisoning by Insecticides: Prevention, Diagnostics and Treatment" (WHO/UBC 84.889, R. Plestina) as a manual. USAID also provided test kits for monitoring cholinesterase levels, which became a significant part of the health protection system during the second campaign. All persons involved in the second campaign were given physical exams as they were recruited; 349 out of 4,607 persons did not pass the exam.

6.1.2. Cholinesterase Monitoring

Although the critical cholinesterase in the central and peripheral nervous system cannot be directly measured with non-invasive procedures, cholinesterase levels in peripheral blood can be used as an indicator for the status of synaptic cholinesterase. AChE in red blood cells is believed to parallel neural AChE more closely than that in plasma, but sample preparation for RBC cholinesterase measurement is more complicated than for plasma AChE. If anything, plasma cholinesterase is a more sensitive indicator for organophosphate exposure than RBC cholinesterase, therefore it is generally used to monitor worker exposure.

During the spray operations, levels of serum acetylcholinesterase (AChE) were regularly measured in all persons involved in the campaign: pilots, navigators, mechanics, technicians, drivers, military personnel and all workers, which included persons involved in pesticide formulation and handling, loaders and ground applicators. Also tested were pilots, spotters and formulation workers. 15 USAID-supplied Lovibond Cholinesterase Kits AF267 were used by Moroccan medical personnel at all the regional command posts (PCRs) to screen all persons for overexposure to OPs every two weeks. When workers showed a depression of serum AChE to 50% - 75% of normal, they were separated from the spray operations for 15 days and were only allowed to return to handling OPs again when a new cholinesterase test confirmed that their levels were above 75% of normal.

Workers whose cholinesterase levels were depressed to 25% - 50% of normal were taken off work with OPs for 3 months while being kept under medical surveillance. Workers with cholinesterase levels below 25% of normal were hospitalized and examined daily. Overall, 4,748 cholinesterase tests were performed during the 1988/89 campaign, and a total of 1,016 persons were removed from the spray operations temporarily or permanently. This number includes 6 pilots, 9 navigators, 18 technicians, 19 mechanics, 22 drivers, 5 military and 933 workers.

6.1.3. Exposure of the General Population

The operational control of the spray campaigns was provided by the Gendarmerie Royale; a part of it was to warn or evacuate inhabitants of the areas to be sprayed. As a result of these precautions, there appear to have been no major health problems in the general population associated with the insecticide spraying. As an additional precaution, random blood samples were collected from the general population for cholinesterase determination. Of almost 500 samples taken, none showed significantly reduced cholinesterase levels.

Moroccan officials pointed out one problem associated with the use of malathion and fenitrothion, and not the use of DDVP: both malathion and fenitrothion are slow-acting insecticides that require considerable time to kill the treated insects. Furthermore, malathion has an irritating effect on the locusts, so after spraying they begin swarming and spread out into non-treated areas. As the locusts settle down outside the treatment area, they may be picked up and eaten by the residents, especially children. Although the population had been warned not to consume any treated locusts, they did not recognize that these have been sprayed, because the insecticide had not yet taken effect. This does not occur with DDVP spraying, because DDVP knocks down the locusts very fast, so treated swarms do not leave the treatment area, and the population will not consume any locusts that have quite obviously been poisoned.

On the whole, this does not appear to have been a major problem, possibly because of the low mammalian toxicity of malathion. Dr. Mahjour indicated that there was only one report of a woman who had become ill after consuming treated locusts.

6.2. The Environment

6.2.1. General

Various aspects of the locust control program have the potential to affect the environment. These include:

- **The spray action itself** which spreads the pesticide throughout the application area and affects non-target organisms as well as the target pest.

- **Pesticide storage sites** which can become sources of significant environmental contamination (i.e.: if stored containers begin to leak and no measures are taken to prevent the leakage from seeping into the ground, or if leakage is washed away with runoff water. They also are sources of airborne pesticide vapors carried in the air.

- **Operational spills**, for example in staging areas during the transfer of pesticides from drums into airplanes.

- **Rinsing and cleanup operations** which generate pesticide-contaminated water which is often disposed of improperly, leading to additional contamination.

6.2.2. Spraying

Of those, the spraying operation itself, dispersing by far the largest quantities of pesticide in the environment, is of main concern. In the case of short-lived organophosphate insecticides, acute toxicity towards non-target organisms (see below) is the primary environmental problem. Since organophosphates are readily hydrolyzed both abiotically and by enzyme activity, they are not bioaccumulated and have no potential to build up to toxic levels in any organisms upon chronic low-level intake.

Contamination of drinking water may be a problem where surface water is used for human consumption. The quantities per acre used for locust control make it unlikely that significant contamination of well water could occur, as degradation of the organophosphate pesticides on treated soil surfaces would be expected to remove the deposited material fairly fast, and the generally arid conditions in the treatment areas did not favor rapid percolation of surface contaminants into the ground. Nevertheless, the GOM analyzed drinking water samples in the treated areas after the 1987/88 campaign. In the waters of the reservoirs of Hassan Dakhil, Mansour Eddahbi and Youssef Ibn Tachfine no detectable amounts of pesticides were found. Low levels of malathion were reported in wells in the Boudenib, Skoura and Figuig areas. However, runoff water from cleaning and rinsing operations is a more likely source of contamination for these water samples than spraying.

6.2.2. Pesticide Storage Sites and Staging Areas

The potential for significant contamination of ground water was highest at the existing pesticide storage sites and in the staging areas where pesticides were loaded into spray planes and tanks were rinsed after spraying. Of the storage sites visited in the provinces of Taroudant, Tiznit and Agadir, the site at the National Locust Control Center of Ait Melloul appeared to have the highest potential of affecting larger numbers of humans, as it is located within the compound of the Center, which is surrounded by dwellings used by Center employees and their families. According to Mr. Ben Halima, the director of the Center, water samples taken from wells on the east and west side of the compound were not found to contain any traces of pesticides, but as a precaution, the water of these wells was considered to be non-potable, and drinking water was brought in from Ait Melloul.

The storage area was cleaned up to some extent-- most of the drums were stored on USAID-provided pallets and some of the stocked material had been transferred into new drums. There was an urgent need for new containers, as many of the stored drums were badly corroded and leaking. At the time of the evaluation, USAID was processing orders for 10,000 new empty drums to be used for redrumming pesticide stocks. As a permanent solution, the GOM was planning a warehouse in

a more remote area which is zoned to remain free of human habitation within a radius of 2-3 km. Mr. Ben-Halima showed plans of the warehouse which will have sealed concrete floors slanting into a central collection gully to allow recovery of any leakage and wash water. The warehouse is to be equipped with forced air ventilation and an automatic fire fighting system. The ultimate storage containers for OP insecticides was not yet determined; the steel drums in use could only be used for a number of years until they would become so corroded that they would have to be replaced. Stainless steel or fiberglass tanks were being discussed as alternative storage containers, but the GOM claimed a lack of expertise in this area and were seeking advice, possibly from pesticide manufacturers.

The other pesticide storage areas visited were more remotely located, typically several miles from human habitation in desert environment. Tiznit and Taroudant are the main storage sites for liquid forms of BHC in the country: the inventory at Tiznit was 279,000 liters (10% and 15% solutions), and at Taroudant 385,000 liters (10% and 15%). At both sites, corroding drums with liquid pesticides lying on their sides in double rows separated by walking space filled up large areas of the fenced-in storage yards. Many drums were developing leaks and the ground under the drums and between the rows was heavily contaminated with leaked pesticide. The air at Tiznit was filled with organophosphate vapors, probably overwhelming the smell of BHC. In addition to the BHC solutions, BHC was also stored in solid form: 32,350 kg of 3% BHC on talc powder and 75,090 kg of BHC-treated wheat bran as bait. The solid preparations of BHC and drums with DDVP, malathion and fenitrothion were stored under shelter and posed no immediate threat to the environment. At Taroudant, the drums in the yard appeared to contain only BHC and no organophosphates; the smell of BHC was very strong. Like in Tiznit, the soil under and between the drums was heavily contaminated with pesticide. In addition to the liquid BHC formulation, 271,440 kg of 3% BHC on talc powder was stored under shelter together with a smaller number of drums with DDVP, some malathion and fenitrothion. Both in Tiznit and in Taroudant the organophosphates intended for use were stored neatly stacked on pallets provided by USAID.

The potential for mobilization of pesticides into ground water was difficult to evaluate without hydrological data; it is probably relatively low at the Tiznit site because of the extreme aridity of the desert area in which it is located. Any organophosphate leaking into the ground is likely to be hydrolyzed fairly rapidly by the alkaline conditions in the desert soil, if sufficient moisture becomes available after rainfall. BHC leaking into the ground, however, will persist for long time periods and may eventually be percolated into the water table. It is worth noting here that a green area with enough water for vegetable growth is located less then 1/2 mile from the storage site in a shallow depression along the access road.

The Taroudant site is located close to the local airstrip in the plain east of the city in the valley of Oued Souss. In the absence of hydrological data for the site, no estimate could be made of the potential to contaminate ground water with BHC leaching from the storage area, but the possibility could not be excluded. In any case, it would be advisable to remove and destroy the BHC from both the Tiznit and the Taroudant site as soon as possible, before too many of the aging drums spill their contents into the ground.

The solid forms of BHC appeared to be stored in a way that posed no immediate environmental hazard; their eventual destruction, however, was a declared goal of the GOM for which it was seeking assistance. According to an inventory compiled at the NLCC, a total of 711,030 kg of 3% BHC on talc powder and 380,690 kg of BHC-treated wheat bran bait awaited disposal.

6.2.3. Analysis of Soil, Plant and Water Samples

Samples of soil and vegetation were taken in the provinces of Agadir and Guelmim 2 to 6 months after the 1988/89 campaign to be analyzed for residues of DDVP, malathion and fenitrothion. Only very few samples had detectable residues: one random plant sample contained 0.2 ppm DDVP, six plant samples contained malathion at levels from 0.5 to 4.1 ppm. None of the soil samples taken in the field had any detectable residues of the three insecticides, and the only soil samples in which malathion (5 ppm) and fenitrothion (3.4 ppm) were found had been taken from the soil of a pesticide storage site at a depth of 1 meter (Arifi, 1991).

Water samples were also taken by the Ministry of Public Health between January and August 1988 and analyzed for organochlorine and organophosphate insecticides. Out of 16 reported samples, 6 had malathion levels ranging from 0.65 to 2.65 ppb (= 0.00065 to 0.00265 ppm), and 3 out of 16 samples had fenitrothion levels of 0.1 to 10.8 ppb (=0.0001 to 0.0108 ppm). DDVP levels for all samples were listed at <80 ppb (<0.08 ppm) (Abouzaid, 1991). In a set of 52 water samples taken in October and November of 1988, only the organochlorine insecticides and DDVP are reported; malathion and fenitrothion are not listed. Again, the DDVP levels are given as <80 ppb. The detection limit of 80 ppb for DDVP appears high, particularly in light of the fact that the authors quote a National Academy of Sciences recommendation of 1 ppb DDVP as maximal admissible concentration for ambient water.

6.2.4. Crop Residue Trial

To study the degradation of residues of the insecticides used for locust control on crops, trials with clementines and tomatoes were conducted in the Massa-Souss valley in November of 1988. Both crops were sprayed by backpack sprayer with insecticides dissolved in high aromatic naphtha (HAN) in ULV formulation according to the following schedule:

Active Ingredient	g A.I. per hectare
DDVP	200
Malathion	750
Fenitrothion	350
Deltamethrin	12.5
Lambda-Cyhalothrin	20

The test plots were sprayed one, two, or three times on consecutive days, and clementines and tomatoes were sampled at 1,2,4,7, and 15 days after the last treatment. Residues of the applied insecticides on and in the samples were measured to determine the waiting periods necessary before the residues had declined below the tolerance levels established for the insecticides by the FAO/-WHO Codex Alimentarius or similar legislature. The results are as follows:

Insecticide	Treat-ment	Clementines Tolerance	Waitg.Time	Tomatoes Tolerance	Waitg.Time
DDVP	1	0.1 ppm	4 d	0.1 ppm	4 d
	2		8.5 d		7 d
	3		>15 d		14 d
Malathion	1	0.5 ppm	7.5 d	0.1 ppm	<1 d
	2		>15 d		<1 d
	3		>15 d		<1 d
Fenitrothion	1	0.2 ppm	10 d	0.1 ppm	2.6 d
	2		>15 d		5.5 d
	3		>15 d		11 d

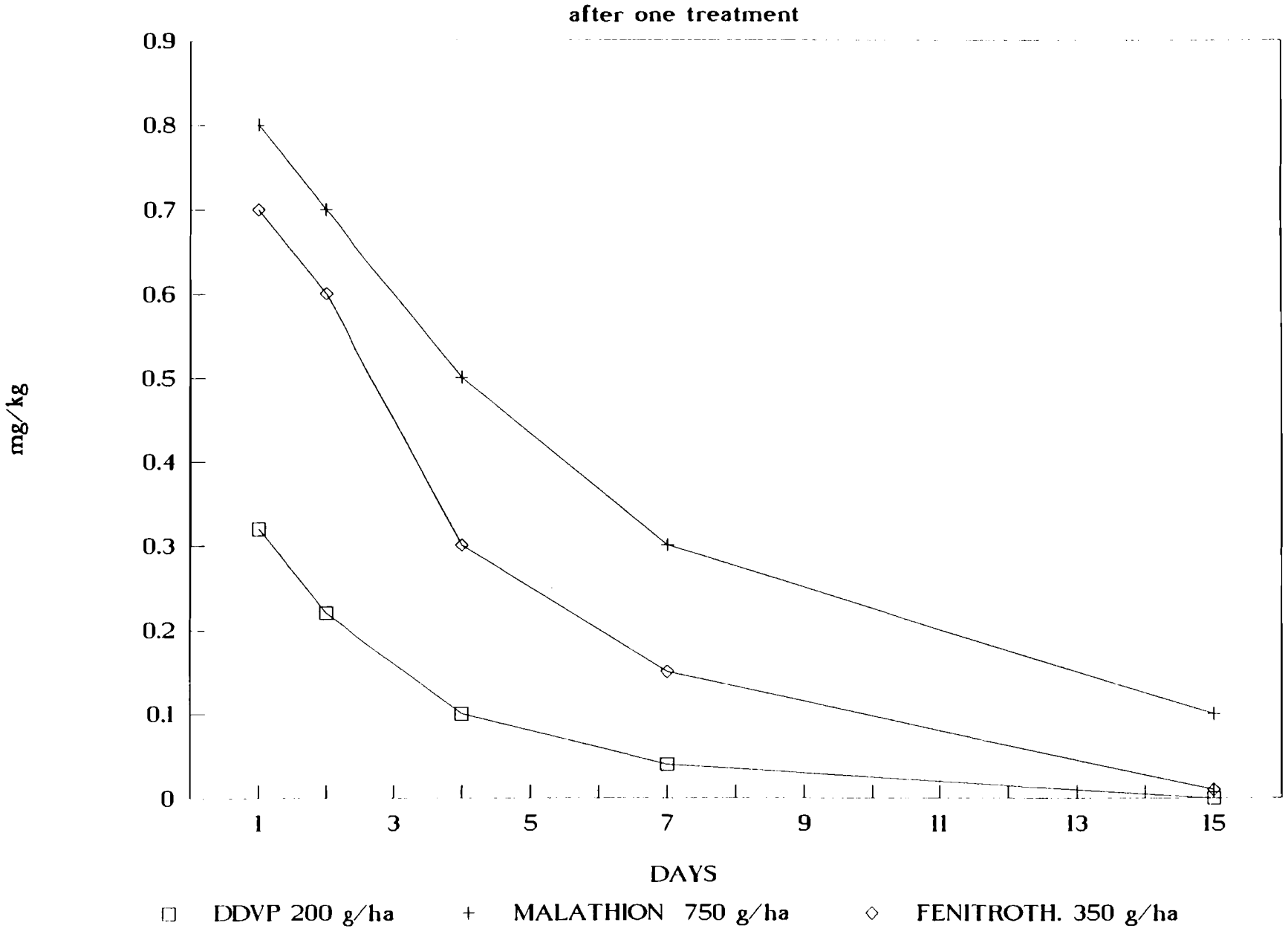
The required waiting periods for the two pyrethroids were one day or less after all treatments. Figure 1 on the following page further shows the decline of residues of malathion, fenitrothion and DDVP on tomatoes over a period of 15 days after a single treatment.

6.3. Effects on Non-Target Species

While the effects of insecticide spraying on humans and livestock could be controlled effectively by well-organized warning and evacuation actions carried out by the Gendarmerie Royale during the campaigns, effects on wildlife, especially birds and small mammals living in the treated areas had to be expected. No inventory of wildlife in the affected areas existed before 1987, and as far as we could determine, no attempt was made to establish a wildlife census between the campaigns of 1987/88 and 1988/89. Desirable pre-and post-treatment data which would allow a direct assessment of the locust control actions on non-target species are therefore not available. USAID's Project Paper Amendment #1 of February 10, 1989 addresses the problem in its Annex C, Chapter 6 as follows: "Although little reliable information is available on this subject, informal field research and observations indicate that program operations to date have resulted in various adverse impacts both on non-target organisms and the natural environment. The Entomologist/Environmental Specialist cites several personal and other source observations which would indicate, at least superficially, that substantive vegetative and non-target organism kills and/or degradation have occurred in program operation areas."

Non-target species of major concern are honey bees and various pollinator insects because of their immediate agricultural importance. Another concern is insectivorous small mammals and bird species, which are jeopardized by consuming locusts and other insects poisoned by the control agents. Morocco is part of a major flyway and winter nesting area of migratory birds like storks which have barely begun making a comeback in central Europe. Predators feeding on small mammals intoxicated by the organophosphates may also be at some risk, if high levels of the insecticide or, in the case of malathion or fenitrothion, the corresponding oxone bioactivation products are present in the prey animals. Generally, however, the organophosphates are not food chain poisons because of

FIG. 1. DECLINE OF RESIDUES ON TOMATOES



their rapid metabolic breakdown by hydrolytic enzymes; consequently bioaccumulation in the environment is not a problem.

6.3.1. Denver Wildlife Study

In 1989 USAID requested the Denver Wildlife Research Center (DWRC) of the US Department of Agriculture to conduct a cooperative project with the GOM's Ministry of Agriculture and Agrarian Reform (MARA) to study the effects of malathion and DDVP on populations of birds, mammals and insects. DWRC in cooperation with the Consortium for International Crop Protection (CICP), USAID/Rabat and MARA conducted this project in two phases. The first phase in 1990, placed emphasis on training. The following five training sessions for Moroccan scientists in ecotoxicological methodology were held:

1. The history, concepts, and conduct of ecotoxicology studies.
   Instructor: J.O.Keith, Wildlife Biologist
   May 21-23, Rabat

2. Methods for organophosphate insecticide residues in field samples.
   Instructor: J.N.Gillis, Residue Chemist
   May 28-30, Casablanca

3. The use of wildlife telemetry in ecotoxicological studies.
   Instructors: L.A. Kolz, Electronics Engineer
   R.L. Phillips, Wildlife Biologist
   June 25-29, Ait Melloul

4. Population Ecology of birds, mammals, and invertebrates.
   Instructors: G.K.La Voie, Mammologist
   M.L.Avery, Ornithologist
   P.C.Matteson, Entomologist
   October 4-17, Ait Bahia

5. Experimental design and statistical analyses
   Instructor: R.M.Engeman, Statistician
   December 12-16, Ait Melloul

The second phase, a field study to determine wildlife effects of malathion and DDVP on experimental plots, was performed in January/February 1992 near Guelmim in southwestern Morocco. Specific goals of this study were to:

1. Determine mortality in birds, mammals and insects, using carcass searches, telemetry, and post-treatment observations.

2. Determine the magnitude of changes in population abundance and structure due to spraying by comparing pre-and post-spray density indices for birds, mammals and insects on treated plots.

3. Determine treatment effects on food habits of birds and mammals, and the influence of changes on emigration, mortality and nesting success. Sampling of food organisms in stomachs, gizzards and feces was used to quantify changes in food habits.

4. Determine treatment effects on reproduction by monitoring nesting success in birds and the incidence of pregnancy, number of embryos, and the number of placental resorption sites versus litter size in mammals.

5. Determine the level of brain cholinesterase (ChE) in birds and mammals to document intensity of insecticide exposure in survivors and cause of death in dead animals.

6. Determine DDVP and malathion residues after treatment in vegetation, insects and foods of both birds and mammals.

7. Determine droplet deposition, spray drift, and meteorological conditions affecting droplet dynamics during treatments.

The site selected for the study is located approximately 15 km northeast of Guelmim, bordered on the north by the river Oued Assaka and to the east and southwest by the mountain ranges of Bou Semgane and Ras et Tarf, respectively. The experimental area had 9 plots with the same vegetation type, similar land features, and no human habitation. The plots were 1.5 x 2.0 km each, with a central 0.5 x 1.0 km sampling area. The plots were assigned randomly to serve as control, or to be treated with 200 g/ha DDVP or 750 g/ha malathion by aerial application from helicopter. The field experimental phase of this study was completed at the time of this evaluation, although the target date for submission of the final project report is June 30, 1992.

6.4. Analytic Capabilities

In terms of analytic capabilities in Morocco, the Laboratoire Officiel d'Analyse in Casablanca has provided special leadership. The laboratory is organizationally placed under the Minister of Agriculture, but as the director, Dr. Laaberki, pointed out, it is set up to function much like a private enterprise. Its budgetary goal is to cover the expense for operation and equipment with income from fees for analyses performed. The lab operations are divided into major sections, one of which is pesticide analysis. The others are: milk and milk products; coffee, tea and spices; canned fish; non-alcoholic beverages; oils and fats; alcoholic beverages; metals; and industrial products.

The laboratory has received support in instrumentation and training from GTZ (Germany) and USAID. The equipment observed by the team appeared to be adequate and kept in good operating condition. There were a number of gas chromatographs with flame ionization, electron capture and thermionic (Nitrogen/Phosphorus) detectors, infrared and UV/VIS spectrophotometers, an atomic absorption and a flame photometer, a high-performance liquid chromatograph (HPLC), and adequate routine lab equipment like balances, ovens, refrigerators and rotary evaporators.

The pesticide lab performs residue analysis for the Department of Agriculture, but also quality control of imported pesticides. To this effort, USAID provided two new Varian gas chromatographs with thermionic detectors for this lab to enable it to perform analysis of field samples for organophosphate and carbamate pesticides. According to Dr. Laaberki, the lab's capacity for residue analysis was about 60 samples per week, but at the time of the evaluation, there was a large sample backlog which caused long turnaround times. He pointed out the

urgent need for education and training of more laboratory personnel as a means of increasing the lab's capacity, and seems to consider this aspect as more important than additional equipment. He stressed the need for more international cooperation in training, both by sending students abroad and by bringing foreign instructors to Morocco to teach courses.

6.5. Summary

The locust control campaigns of 1987/88 and 1988/89 were well organized and effective; while the first campaign appears to have been an emergency response to the invading the locust swarms, the Moroccan authorities were ready to deal with the second invasion in fall of 1988. USAID contributed significantly in the areas of human safety and environmental assessment. The Moroccan officials we met stressed the importance of the protection kits and the cholinesterase test kits for the safety of all personnel involved in the spray operations. The very impressive figures illustrate this point best: while during the first campaign more than 400 persons had to be treated or hospitalized for symptoms of organophosphate poisoning, only 23 persons became ill during the second campaign. This must be credited partially to the excellent health care and safety education system established by the Moroccan Ministry of Health for the second campaign, but the availability of protective gear and the cholinesterase kits were definitely critical factors in avoiding overexposures. There is no doubt that many of the over 1000 workers that were temporarily or permanently suspended from working with the insecticides would have developed symptoms of organophosphate toxicity if their exposure had been allowed to continue unchecked.

In terms of assessment of the environmental impact of the locust control operations, the USAID-commissioned study of the Denver Wildlife Research Center promised to be a very important contribution to the elucidation of the effects of organophosphate insecticides on ecosystems in arid environments has the potential to serve as a model for prospective environmental impact assessments of pest control in many other arid and semi-arid areas. While it is deplorable that no attempts were made to obtain pre-and post-treatment wildlife counts for the 1988/89 campaign, the training of Moroccan biologists in ecotoxicological assessment techniques put the host country in a position to set up and conduct such surveys in future operations.

USAID continues to play an important role in assisting the Moroccan authorities in minimizing the environmental and health impacts associated with the storage of leftover insecticides. This has developed into a very serious problem, not so much because of USAID-supplied pesticides, which have been essentially used up during the campaigns, but because of older stocks of insecticides, including technical BHC, that have been stockpiled for up to 30 years. Morocco needs assistance in dealing with these old stocks, and the authorities appear to be ready to approach the enormous task of destruction and cleanup.

Finally, the GOM never failed to stress the importance of the education and training that USAID has provided. This indeed seems to be the most important and constructive legacy that actions like this past locust control program can leave behind: groups of trained experts ready to deal with problems of the future.

CHAPTER VII. OTHER ISSUES

This sections details the teams findings with respect to other issues and items of importance in the MLCP, namely:

- USAID's overall response to the problem
- USAID's responsiveness to GOM requests
- the issue of regional cooperation
- human resource development
- the validity of the economic assumptions in the Project Paper

7.1. USAID's Overall Response to the Problem

USAID's response to the initial invasion was immediate and comprehensive. Upon receipt of a request for disaster assistance from the U.S. Ambassador to Morocco, the Office of Foreign Disaster Assistance (OFDA) moved almost overnight to purchase and air freight pesticides, lease application aircraft and provide experienced personnel for technical assistance. Assistance from AID and other donors and funds provided from Morocco government sources came so quickly that it does not appear that Morocco had to even consider a request for the release of funds from the FAO, Northwest Africa Locust Control Commission emergency fund.

As the infestation expanded in the spring and fall of 1988, OFDA continued to provide immediate additional support. However, since OFDA is limited as to the time it can participate in a single emergency, continuation of AID assistance was passed on to the ANE Bureau. The resultant longer-term plan for assistance, the MLCP, was comprehensive in its scope, and provided for the transfer of expertise in areas which had not before received a great deal of attention (i.e.: human health and environmental monitoring). For dealing with such emergency situations, AID Bureaus are generally ill-equipped to react quickly as is often required. Though under the MLCP, USAID may not have been able to provide the quick responses that it was able to through the OFDA mechanism, the team was generally very impressed with USAID's continued responsiveness. This is a credit to the participating AID offices which are not structured, as is the OFDA, to respond to emergency situations.

In the future and in cases where long term emergency actions involving more than one AID Bureau exist, USAID may consider the establishment, through OFDA, of a regional task force which would bring all USAID activities related to the emergency under a single center in Wash D.C. with a director, representatives of each concerned Bureau, technical specialists, administrative and support staff--essentially combining the capabilities of both the OFDA and the regional bureaus.

7.2. USAID's Responsiveness to GOM Requests

According to Moroccan officials, USAID/Rabat responded positively and efficiently to GOM requests. In all meetings, Moroccan officials expressed their gratitude for AID's contributions, referring to the important and crucial role the Agency played in helping Morocco control the Desert Locust invasion. AID assistance was generally rapid: commodities and treatment aircraft arrived in due time; pilots

performed in a superior fashion; and aerial treatment was efficient.

Among all AID contributions to the Desert Locust campaigns, Moroccan officials have specifically expressed the following positive points (stated in order of importance):

1. Since Morocco's Locust control strategy is offensive, aerial treatments conducted by USAID aircraft was swift and effective. In particular, the provision of DC7s aircraft was considered by Moroccan technical personnel as the decisive factor in breaking the locust invasion-- allowing treatment of settled swarms on very large areas within only few hours was essential to stopping further movement of the very mobile gregarious adults.

2. The supply of cholinesterase sets were very valuable to monitor exposure of field agents dealing with pesticides. These sets not only proved to be effective technical tools in that they permitted local authorities to identify, treat and, if necessary, remove exposed workers, but they also greatly facilitated understanding and the promotion of human health and safety.

3. Owing to the stated preference for DDVP, the supply of Malathion pesticide was considered to Moroccan officials as positive contribution in terms of quantity, but preferring DDVP, not quality.

4. The supply of Greenness maps was considered as valuable in defining areas having favorable conditions to the reproduction of DL, thus aiding in the identification of areas to receive greater surveillance.

5. The supply of empty drums for the transfer of liquid pesticide from older leaking and dented drums.

6. Finally, they noted the Denver Wildlife experiments which allowed the DPV to participate for the first time in an environmental study, providing much needed exposure to the use of sophisticated equipment and the means to be able to assess damage to the environment. As a measure of its impact, their increased awareness and use of pesticides that have the shorter environmental persistence was cited.

In sum, Morocco officials were most appreciative of USAID assistance, and clearly expressed their belief that, without AID's contribution, the country would have lost a significant portion of its agriculture production.

Nonetheless, Morocco officials did cite some weaknesses with respect to AID contributions. These included a lack of or slow responsiveness on the part of AID after the invasions, especially in comparison to that evidenced during the locust control campaign. For instance, despite Morocco's presentation of several projects requiring USAID assistance (though admittedly informal), there was no determination (positive or negative) made. These projects concerned:

- Building of 4000 m^2 covered shed for pesticide storage in Agadir;
- Building an underground reservoir for solvents in Agadir port;

- Construction of a training center in Ait Melloul as a part of the NLCC;
- Procurement of an incinerator to burn left-over BHC stock.

Though the team generally felt that without submission of formal proposals for the above, there was little reason to criticize AID's response, the team also felt that AID should assist Morocco in at least beginning to formulate plans for addressing the serious problems of pesticide storage and disposal.

Finally, there were also opinions expressed with regard to the choice of pesticides. Notably, and in opposition to the position of AID-experts, Morocco technical officials also considered the supply of carbaryl Seven-4-oil as unsuccessful. Moroccans believe that locust mortality rate for that pesticide is very low against hoppers (not exceeding 30%), and also cited the practical difficulty in using and applying the formulation which was discussed previously. In addition, although cognizant that AID's refusal to permit American aircraft to use pesticides other than malathion was related to the Agency's respect of EPA regulations, Moroccans felt that the use of only malathion in aerial applications would have negatively affected the locust control operation.

7.3. Human Resource Development

The on-the-job training which resulted from the 1987-1989 locust campaign in Morocco produced a large cadre of personnel experienced in all phases of locust control. As the nature of the project limited the number of Moroccan nationals that received training in other countries, short-term consultants provided much needed insight and further broadened the experiential base. This included: the training of application specialists; the environmental monitoring training provided by the Denver Wildlife ecotoxicology project to a large number of Moroccan technicians and scientists; and the training and experience gained by the Ministry of Health personnel in cholinesterase monitoring and poison control.

In terms of continuing needs, additional training requirements were identified for the following areas:

1. Pesticide management and storage
2. Hazardous waste disposal
3. Additional methods for pesticide analysis
4. Pilot training
5. Advanced ecological monitoring

It was also mentioned that a technical writer is needed to help in preparing a manual on the techniques and results of the cholinesterase testing program.

Finally, team members felt that the vast experience base should be preserved and further developed. Means for accomplishing this may include holding periodic conferences, workshops and symposia covering all aspects of the campaign, as well as providing for field exercises and simulations. Such activities would assist in assuring a transfer of knowledge and experience from campaign veterans to new personnel, and could provide a forum for integrating counterparts from other countries. They could also be useful for obtaining further international expertise, and in refining and updating and operational plans.

7.4. Regional Cooperation

As developed in previous sections, national locust control programs will, at best, be marginally successful if they are not part of a larger regional effort of monitoring and control. The following outlines some of the past and current efforts undertaken to achieve such a regional program.

7.4.1 Regional Conference

Recognizing that problems existed in the overall locust control strategy, in both Morocco and on a regional level, King Hassan II called an international conference on locust control in Fez, Morocco in October, 1988. At this conference the Director of the OFDA, Julia Taft, proposed the establishment of a strategic strike force made up of participants from affected nations. The strike force would have authority to work in nations and locations that were presently considered out of bounds to survey and control action. This proposal was enthusiastically endorsed and a committee established to design the strike force and its terms of reference. In its enthusiasm, the design team far exceeded the original proposal. After several rejections of draft proposals, the locust problem subsided and the need for the strike force diminished. However, the need for such a strike force may escalate in the future so work needs to continue on a practical design.

7.4.2. Current Efforts

Morocco is one of the five Maghrebian members of the Desert Locust Control Commission for N.W Africa, known as CLCPANO. Morocco is also a very active participant in many regional and international bodies concerned with locust control. The following discusses two regional cooperation projects.

7.4.2.1 Maghrebian Force (FMI)

In addition to contributing financially to individual country program, BID and FAO assisted in the constitution of a Maghrebian Force, known as FMI (Force Maghrebine d'Intervention). FMI was created in Nov. 1989 and continues to function through funding by FAO & CLCPANO. Member countries include Morocco, Algeria, Tunisia, Mauritania, Niger and Mali. A basic component of the Force relates to the constitution of mixed teams represented by one or more agents from each country concerned. The purpose of this force is to monitor the Desert Locust situation in the recession zones of sahelian countries. Surveys are carried out during the months of August, September and October and during the spring in March and April. Within the breeding areas of Northern Mauritania, 6 teams are in operation-- each composed of one Moroccan and one Mauritanian technician and each is equipped with vehicles. Continuation of that force is dependent on available funds from the FAO & CLCPANO, and recognizing the importance of the effort, Moroccan officials have expressed their desire for donors to continue their support.

7.4.2.2. Inter-Regional Preventive Control Project

FAO and FIDA are also working on the elaboration of an inter-regional project involving 8 countries: Mauritania, Mali, Niger, Chad, Morocco, Algeria, Tunisia,

and Libya. The project of a proposed duration of 5 years, aims at ensuring permanent preventive control against Desert Locust in West and North-West Africa. It has the following four principle components:

- Reinforcement of national entities responsible for locust control
- Development of institutional coordination between OCLALAV and CLCPANO
- Support of research in acridology; and
- Supply of treatment materials.

The project was still being prepared at the time of this evaluation, and Moroccan officials were most interested in participating in same.

7.5.1 The Validity of Economic Assumptions in the Project Paper

Assumptions in the Project Paper to the MLCP related to the economic impact of the project were based mainly on the calculation of losses due to locusts consumption of the value of vegetative matter. It relied on the premise that an adult Desert Locust consumes vegetative matter equivalent to its total body weight each day (2 grams), and that a medium size and density swarm will contain 50 million locusts per km2, consuming a total of 100 tons of vegetative matter per day. It further estimated that in March, when blossoming and grain head formation is at a peak, the value of expected crop loss will amount to 403.2 DH per ton of locusts per day for a swarm containing 2 tons of locusts per ha. Assuming that the locusts remain as immature adults for at least 10 more days (the stage at which they inflict the greatest damage) a swarms damage potential is $1,000.00 US.

The above figures and assumption are very problematic. Two tons of locusts per ha. (200 tons per km2) is at least twice the number generally attributed to a moderately sized locust swarm. The figures are also dependent upon suitable conditions for locust maturation in that locusts can remain as immature adults for a rather extended period of time (several weeks to months). They may also be misleading in that, generally-speaking, there are far more swarms of lesser density than that cited. Moreover, a certain amount of vegetative pruning by locusts may actually be beneficial rather than detrimental.

Regardless of these points, Moroccan agricultural productivity, particularly in the spring, is at great risk during a DL invasion. The spring invasion period coincides with blossom time for citrus and stone fruits, and seed head development of the principal cereal crops. In such a situation, a relatively small number of locusts could destroy the blossom and decimate a year's fruit production. Similarly, locusts can cut off the newly formed grain heads of cereals which fall to the ground and are lost while only a rather small amount of vegetative matter is consumed. The increased potential for agricultural loss during a spring invasion in no way, however, obviates the need for control operations in the fall. For even though the value of crops lost during fall invasions will more than likely be less than for spring invasions, if the progeny produced during the fall are left uncontrolled, they will be present in the spring when the crops are most vulnerable.

Disregarding the validity of specific assumptions, the effectiveness of the

Desert Locust control program appears to be clearly demonstrated by the increase in the production principal food and cash crops during the invasion years. The following table presents some production figures taken from the Moroccan Agricultural Statistics Service publication.

Table 7.5.1. PRODUCTION IN 1000 QUINTALS

Overall	1986/87	1987/88	1988/89
Cereals	43,125.8	79,393.3	74,088.9
Legumes	3,137.1	4,502.2	3,473.4
Citrus	960.0	1,233.0	1,444.0
Southern Morocco	**1986/87**	**1987/88**	**1988/89**
Cereals	1,257.0	4,668.8	2,311.8
Legumes	8.9	8.7	17.3
Citrus	5,010.0	5,540.0	6,054.0

Increased production may to a certain extent be attributed to increased planted hectarage due to favorable rainfall. Nonetheless, in spite of the planted area increase, a substantial reduction in citrus production and lesser increases in cereals and legumes would have been expected, if significant locust damage had occurred. Based on these figures alone, it would appear that the locust control program had significant economic benefits.

7.5.2. Locust Control Program Cost

Morocco calculates the total cost of the program at 740 million DH ($ U.S. 84 million) of which 174 million DH was provided by donors. On a per ha. basis, however, the estimated cost of the Morocco program varies greatly among the nations and agencies involved. A cost of $30.00 per ha. as an average overall cost of the global Desert Locust control effort is utilized in some FAO papers. For the MLCP, the Project Paper used a figure of about $24.00 per ha. The Government of Morocco itself uses the figure of $15.36 per ha. with Morocco's cost being $9.15 per ha. or 59.57% for the period of October 1987-July 1988,* and after completion of the three campaigns, only about US $ 10.00 per ha.** Some of the difference may relate to accounting for non-expendable property. Whereas the Project Paper appears to have divided the total overall expenditure by the number of ha. treated, the Moroccan calculation provides for depreciation of non expendable items over time. Such items provided by USAID which will be available for locust control and other crop protection activities in the future, include:

Sprayers and mist blowers	$ 1,000,000
Helicopter application systems	$ 150,000
Radios	$ 220,000
Protective clothing	$ 122,000

* A. Arafi, 1988.

** A. Arafi, 1991.

The Moroccan calculation does not, however, provide for personnel salary, benefits and travel costs. Further compounding the problem of cost calculation, the number of ha. sprayed is based on the quantities of pesticides used and the approved application rate. Repeat applications and loss through spillage thus merely add to the number of ha. treated. Given these various assumptions, the actual per ha. cost may, therefore, never be accurately calculated. Though clearly debatable, the team would advance that the $15.36 per ha. cost is probably somewhat low, while the $24.00 per ha. figure too high and, somewhere between $19.00 and $20.00 would be a more realistic per ha. cost.

CHAPTER VIII. OVERALL TEAM FINDINGS

The evaluation team addressed the locust control in Morocco in a global approach where all findings and analysis are discussed in detail in previous chapters. The following discusses the team's finding with respect to the project's specified outputs, the evaluation of which was highlighted in the "statement of work" to the final evaluation.

8.1. Enhanced capacity to control DL through aerial spraying of insecticides:

During the three campaigns, Morocco treated in total about 4.8 million ha. using aerial and ground treatment against Desert Locust adults and hoppers. As concerns aerial spraying, the Moroccan operational capability clearly increased, from 2,000 ha. per day before the 1987 invasion to a peak average of about 32,300 ha. per day in November 1988, eventually accounting for about 77% of the total area treated. To this effort USAID supplied the flying hours of two Turbo Thrushes, two DC-7s and one C-130.

An important aspect of the GOM's enhanced aerial spraying capacity, which reached 93.5% of the total area treated during the 1988 campaign, relates to the use of larger aircraft, such as the USAID-provided DC-7s. These aircraft accounted for approximately 30% of total area sprayed, and it was only through the addition of these larger airplanes that it was possible to reach the capacity required.

It may be further noted that even though the registered increase was due in large part to donor assistance, the maintenance of personnel, equipment and material stocks has allowed the GOM to maintain this capability, which at the time of the evaluation was estimated to be about 20,000 to 30,000 ha. per day.

8.2. Improved strategic planning and tactics of control, including preparation for appropriate responses north of the Atlas mountains:

The patterns of locust invasion in the spring and fall of 1988 came mainly from the movement of swarms developed in northern Mauritania, while those that entered Morocco in early 1989 came almost entirely from along the coast. As demonstrated by the fact that swarms were eliminated before they could cross the Anti-Atlas mountains, the adopted control strategy was successful in providing Morocco the desired level of protection to its crops.

The failure of invasions to continue in the fall of 1989 and later did not allow a full test of GOM capacity, especially as concerns the preparation of responses north of the Atlas mountains. The few scattered locusts which did reach Fez were immediately eliminated. However, based on the GOM response in other areas, there is no reason to believe that their response would not have been efficient and effective if a problem had occurred. The organizational flexibility of the locust control operation was such that redeployment of application equipment could have been achieved over long distances within a few hours. In addition to aircraft designated for locust control operations, commercial Moroccan aircraft were also available in principal agricultural areas for general plant protection use. Personnel from various government agencies from throughout Morocco were

rotated through the control effort in the south, so there was a supply of experienced personnel readily available. Operational sites had also been identified in the event of need, and medical facilities with personnel trained in the diagnosis and treatment of pesticide intoxication were available. Communication facilities were adequate; commercial transportation readily available; and numerous suitable airstrips were present and operational.

Much of Morocco's improved capability to plan and execute a control strategy may be attributed to the national organization that was developed-- a structure which may be described as functional, comprehensive and well-adapted to Moroccan conditions. It was also characterized by a high degree of cooperation among the concerned governmental services and agencies. Morocco's strategy and tactics of control were, however, more a result of professional crises management rather than a result of a long-term plan of prevention and control. The success of future monitoring and control efforts will depend not only on Morocco's internal level of preparation, but also on their success at working with their neighboring countries on the development of collaborative detection and control strategies.

8.3. Improved efficiency of operations such as survey, treatment and communications:

Based on the above, the team felt that the GOM's capacity for survey, treatment and communications increased dramatically as the campaigns progressed, and that the GOM would be well-positioned to undertake a similar campaign in the near future. The total increase in treated area by the GOM can be attributed in large measure to the proper application by the well organized control organization of all the inputs of both GOM and donors. The volume of work successfully accomplished without any serious reported incidents speaks well of the efficiency of the activity. USAID, as one of the major contributors of aircraft, technical personnel, pesticides, "greenness" maps, and equipment for communications, safety and ground support certainly improved the effectiveness of all operations.

Future campaigns should, however, make more use of control methods such as ground treatment and the "Barrier Strips" technique for hopper treatments. The team also questioned the use of the pesticide DDVP by the GOM, and recognized USAID's strong objections to its use as an important, albeit largely ignored, technical input. Finally, in light of the greatly diminished DL threat, the team questioned the validity of maintaining, for the sole use of future DL campaigns, important vehicle, equipment and material stocks. The team felt that these inventories could be used for other, more immediate needs within the agricultural sector.

8.4. Improved GOM capacity for the management and monitoring of environmental, safety and health aspects of control operations:

In the area of human safety, USAID made several significant contributions to the GOM capacity to manage and monitor human health and the environment. These include:

- provision of protective clothing, cholinesterase test kits, and training in cholinesterase testing. These contributions, combined

with the excellent health care and safety education system established in Morocco, resulted on the reduction of number of treated persons for symptoms of organophosphate poisoning from over 400 persons during the first campaign to 23 cases during the second campaign.

- financing of an environmental impact study concerning DDVP and malathion, and which was being conducted by the Denver Wildlife Research Center. Though incomplete at the time of the evaluation, the study promises to provide important information on the effects of the two main organophosphates pesticides used in Morocco. In the absence of pre-and post-treatment wildlife counts, the results of this study are of crucial significance for the environmental assessment of future control campaigns.

- efforts to improve the conditions of storage of older pesticides. USAID's contribution in this area, as well as pesticide management in general, greatly assists in reducing the potential for environmental contamination. Although the provision of wood pallets as drum storage platforms and empty drums to redrum pesticides from leaking containers can only be temporary solutions, these nonetheless reduce uncontrolled contamination of soil and ground water, and provide for more accurate monitoring.

- the training of Moroccan biologists in techniques of ecotoxicological assessment and analytical chemists in pesticide residue analyses are also very important aspects of AID actions, generating sustainable expertise which will be crucial for future pest control programs. Likewise, the installation of two gas chromatographs with phosphorus specific detectors enables the official laboratory in Casablanca to provide the needed residue analyses for organophosphate pesticide in-country rather than having to send samples abroad for residue analyses.

Emanating from the above has been a greatly heightened environmental awareness at all levels of Moroccan government. Though based on anecdotal information, concern for the "flora and fauna" was expressed not only during the team's initial meeting with the Gendarmerie Royal Coordinator of the PCC, but during interviews with personnel throughout the country.

CHAPTER IX. RECOMMENDATIONS

Based on the team's findings, the following recommendations for action are presented. Recommendations are segregated according to the principle sections of this report, although one additional recommendation area, that concerning human resource development, is also provided.

Organizational Structure:

1. The institutional structure that GOM developed proved to be an effective and efficient approach to control locust, and there exists a bond among the agencies involved that should remain for some time. This approach could serve as a model on how to harmoniously combine scientific and technical units with disciplined organization and support. The GOM should conserve this institutional structure, and USAID should study its applicability to future locust control efforts in other countries. As a part of conserving the institutional structure, the team recommends the continued functioning of the PCC as the nucleus for rapid mobilization of resources and personnel for future locust invasions.

2. Though the institutional structure for locust control should be conserved, given that there is no current DL threat, and in order to restore resources which were diverted to the locust control effort to their traditional use, the NLCC should be returned to MARA. The technical capacities of the NLCC could be better utilized for training and research under the direction MARA, and the Center's important vehicle, equipment and material stocks could be directed to more immediate needs within the agricultural sector.

3. With regard to USAID, in cases where long term emergency actions involving more than one AID-assisted country exist, consideration should be given to the establishment, through OFDA, of a regional task force which would bring all USAID activities related to the emergency under a single center in Washington with a director, representatives of each concerned Bureau, technical specialists, administrative and support staff-- essentially combining the capabilities of both the OFDA and the regional bureaus.

Operations and Applications:

4. Because of the importance of communications during spray operations, USAID should assist the GOM in improving the compatibility of the radio equipment for field operations. With regard to specific procurement actions for communications, USAID should consider supplying a certain amount of spare parts and antennas compatible with frequencies used in Morocco for the USAID-provided radios.

5. In light of observations regarding the lack of communications equipment made available to marking personnel, the GOM should identify the reasons for this problem and make provisions for correcting same.

6. USAID should also consider support of a feasibility study for establishing GPS (Global Positioning Satellites) navigation systems and swath spacing for locust control operations. Spray-aircraft guidance is an important unsolved problem in Morocco and the rest of Africa.

Survey and Control:

7. Given the usefulness of the Greenness maps to the Crop Protection Service (for locust control and other activities), USAID should assure their continued supply.

8. Considering that Morocco is not a recession zone for Desert Locust, but rather an invasion zone, the success of any DL control effort is dependent upon reliable information from neighboring countries. In light of this, it is recommended that Morocco continue to participate in the regional cooperation projects such as the Maghrebian Force (FMI) and the planned Inter-Regional Preventive Control. This will allow Morocco to monitor early DL population build-up and avoid unanticipated invasions. USAID and other donors should be highly supportive of such efforts.

Pesticide Management:

9. Although the locust threat has passed for at least the immediate future, the problem of short and long-term pesticide storage remains. The team suggests the following four options:

    a. Use on other plant protection activities where ULV application is feasible.

    b. Reformulation into products such as emulsifiable concentrates that can be used on a wide number of pest problems and in both simple and complex dispersal systems.

    c. Sale or transfer to other countries that could use the product within a short time. Primary consideration could be given to nations that harbor migratory pest problems that could pose a threat to Moroccan agriculture, such as army worms.

    d. Destruction according to the best available technology (i.e.: cement kiln, incineration, etc.).

10. Within the above framework, USAID should provide assistance to the GOM in developing a plan for the safe and environmentally sound disposition of, at the very least, those surplus pesticides they provided, especially malathion. Though not necessarily a result of USAID assistance, other areas which could be addressed include: the disposal of empty containers, leaking containers and pesticides which are no longer approved for use in most countries.

11. The above is not to suggest that USAID assume the full burden of pesticide management in Morocco. The issue is very complex, and the problem too large for any one agency. Nonetheless, given USAID's expertise, there are

areas in which USAID could greatly facilitate Morocco's management of the problem. These include:

- assistance in establishing a panel or committee of national experts and representatives from USEPA, pesticide manufacturers, OSHA, academia and other agencies to work on the development of a detailed pesticide management plan. Such a panel or committee could more adequately evaluate the pesticide storage and disposal options presented in this report (i.e.: redrumming, burning in a cement kiln, incineration in a mobile facility, etc.).

- training of one or more Moroccan specialists in the U.S. in the field of pesticide management. Such training should include exposure to manufacturers, regulatory agencies, universities, pesticide applicators and disposal experts.

12. Given that there is still no commonly preferred method for locust control, USAID should continue to support research aimed at developing new and innovative pest management systems that lessen the need for pesticides, as well as pesticides or combinations of pesticides which provide quick knockdown and mortality of the pest, low mammalian toxicity and improved environmental qualities.

13. Redrumming of pesticides presents many hazards during the decanting process as well as with regard to the disposal of the empty discarded drums. It is at best, a temporary solution to a long-term problem. Nonetheless, as consideration is given to redrumming surplus pesticides, the new drums should be clearly marked with the original date of manufacture, the expiration date, the date of redrumming, the manufacturers name, the product name, the lot number, concentration percentage of the pesticide, and formulation on each barrel. Preferably the entire original label including hazards associated to its use and approved safely measures should be included in the official language of the country.

Human Health and the Environment:

14. USAID should encourage continued availability of cholinesterase kits in Morocco, particularly during similar locust control operations, as well as the continued testing of individuals assigned to pesticide storage facilities. Moreover, given the importance and successful nature of this intervention, USAID should strongly consider funding a technical writer to prepare a quality scientific publication on the cholinesterase testing component of the MLCP.

15. In terms of ground water contamination, more attention needs to be focused on containing the high aromatic naphtha (HAN) solvent. It may cause more long-term harm to ground water than the organophosphate insecticides, which have limited lifetimes due to hydrolysis.

16. USAID should encourage the development, perhaps through the FAO, of climate-specific specifications for protective gear for pesticide handlers in order to provide more appropriate equipment for future campaigns.

17. USAID should encourage the Moroccan biologists that were trained by DWRC to establish and maintain a wildlife census that can serve as a pre-treatment count for future campaigns. USAID could also play a role in assuring continual contacts between DWRC and Moroccan officials.

18. The capacity of the existing pesticide residue laboratory in Casablanca should be expanded to accommodate the increasing number of environmental samples, and to assure shorter turnaround times. In addition to assisting with the purchase of additional equipment (i.e.: for pesticide residue analysis), USAID could take a lead in helping to arrange training of Moroccan analysts in the U.S. and in bringing U.S. instructors to Morocco.

Human Resources Development:

19. Considering the NLCC's technical expertise in acridology, as well as the continuing need for technical training and research in that field, it is recommended that this Center further develop its capabilities to provide training to field agents, support research activities, and act as a central point for the collection of pertinent documentation and information on locusts. Such a capability would serve not only Morocco's interests, but also those of neighboring countries.

20. In light of Morocco's relatively successful locust control experience, as well as its desire to increase cooperative control efforts with its neighbors, the team recommends that an international conference be held in Morocco with specialists from each concerned country, international scientists and other experts.

21. USAID should continue to support Morocco's locust control effort through the provision of short-term training in certain fields. These include:

- acridology
- pesticide management/hazard wastes
- pesticide application technology
- pesticide residue analysis
- pilot training
- environmental toxicology

GOM beneficiaries of such training would not only assist Morocco in addressing current issues (i.e. pesticide management) and in preparing for future DL invasions, but could also be important technical contributors to regional programs, such as the FMI and the anticipated FAO Inter-Regional Preventive Control Project.

22. In order to maintain the level of experience and expertise gained during the past campaigns, the GOM should organize periodic workshops and training exercises which involve all the various governmental bodies and which utilize personnel who were involved in latest campaigns. To the extent practical, simulations should also be organized, perhaps including a limited amount of helicopters and fixed wing aircraft flight time, as well as radio communications checks, marking trials, etc.

CHAPTER X. LESSONS LEARNED

Based on the above analyses, and segregated according to the main sections of this report, the following are the principle lessons learned identified by the evaluation team:

Organizational Structure:

1. The specific structure of the National Organization that managed the locust control operations proved successful, efficient and well-suited to the political, economic and social conditions in Morocco. The organization was by no means perfect, especially in its initial stages, but clear improvements were registered as agents and institutions gained valuable field experience. Such experience, which is only available through participation in an actual campaign, will significantly increase the effectiveness of future control operations.

2. The highly disciplined form of organization in Morocco, characterized by some as military in style, produced many more positive results than negative. Quick and authoritative action is especially important in Desert Locust control because of the fast and often long distance movement of swarms.

3. After a DL threat has subsided, the continued functioning of a national locust control organization, albeit at a much reduced level, is useful in not only maintaining a degree of preparedness, but also in resolving pending related issues (i.e. pesticide management) and in keeping important issues such as regional cooperation at a high administrative level.

Operations and Applications:

4. The USAID supplied aircraft and personnel functioned well with the GOM organizational arrangement and were effective in control operations. The chemical loading equipment and radios contributed greatly to the safety and efficiency of operations. Given U.S. expertise in these areas, similar contributions should be considered for future campaigns in other countries.

5. Although spraying with large multi-engine aircraft is often considered as overly risky in terms of potential harm to human health and the environment, their use in relatively unpopulated and non-agricultural areas should not be discounted. In the case of Morocco, the rapid treatment of large invading swarms by the DC-7s, which provide 10 times the spraying capacity of typical treatment aircraft, was a critical factor in swarm control.

6. With regard to other aircraft, the Turbo-Thrush aircraft proved to be highly suitable for locust control due to their power, maneuverability and relatively long range. As well, helicopters should be considered as an

essential part of any DL control operation. They are valuable tools in the detection and tracking of swarms, for guidance of spray aircraft to their targets, and can be used for spray application in areas too difficult for access by fixed wing aircraft. The unique capabilities of helicopters should be exploited to the greatest degree and be available early.

7. Exhaust nozzle sprayers, though sparsely used and considered antiquated by field operations technicians, are an efficient control tool with only minimal maintenance problems-- providing a high degree of safety to the operator and requiring very little advance training for their operation. If local acceptance of such equipment is low, as in Morocco, measures should be taken to increase their use (i.e. training, official agreements, etc.).

8. In future locust control projects, USAID should provide for certain inspection services in order to assure compliance with USAID policy (i.e.: with regard to pesticide use and application). Without such inspection, and in the midst of a large control operation, it is unlikely that managers and technicians will abide by or maintain awareness of all of the regulations and procedures which are and should be imposed.

Survey and Control Strategies:

9. The problem of Desert Locust is highly complex. What occurs in one region will ultimately affect other regions. Therefore, the strategies and actions of individual countries will not be successful in breaking a plague. A regional cooperation approach is required. Morocco has initiated needed cooperative action with nations to the south, but much remains to be done if an effective plan for DL monitoring and control is to be developed.

Pesticide Management:

10. With regard to the procurement of pesticides for similar programs, and given both the potential harmful impact of unused pesticide stocks, as well as the cost of their storage and disposal, quantities should be ordered on an "as-needed" basis to the extent possible, and the procurement of surplus or emergency stocks should be avoided. To this end, consideration should be given to air freighting pesticides, the additional cost of which may be small when compared to the costs of surplus pesticide disposal.

11. Given problems associated with surplus pesticide stocks, a generic pesticide management plan should be developed by AID/W, updated annually and made available to the missions. From this, a detailed pesticide management plan, adapted to local conditions and agreed to by host governments, should be developed for each future project in which pesticides are provided. Some of the items which should be included in such a plan are:

- designation of storage sites, disposal sites, facilities,

equipment and systems.

- detailed description of procedures for pesticide receipt, handling, transport, storage, drum disposal, and disposition of surplus stocks.

- on-site inspection program to ensure continuous compliance with USAID regulations.

- a firm commitment from the host government as concerns proper disposal of any surplus or waste and empty pesticide containers in a manner consistent with AID policy.

- a procurement plan in order to keep in-country prepositioning of pesticides to a minimum.

12. In order to avoid some of the pesticide management problems which Morocco currently confronts, the following items should be noted:

    - care should be taken to clearly mark pesticide containers (i.e.: with type, manufacturer, date of manufacture, expiration date, lot number, etc.).

    - as pesticide drum damage increases with each transfer from location to location, any method to reduce damage (i.e.: portable ramps, barrel hoists, etc.) should be employed.

    - while barrels are the most convenient containers for use on locust control projects, bulk shipments and returnable containers (mini-bulk) should be given preference.

Human Health and the Environment:

13. With appropriate training and frequent cholinesterase monitoring even highly toxic insecticides can be handled safely and with minimal untoward effects on the applicators. Providing cholinesterase kits proved to be a very cost-effective way for USAID to improve significantly the safety of the spray operations, and the provision of such kits should be a standard input into projects using large quantities of pesticides.

14. In locust control campaigns such as that in Morocco, it is virtually inevitable that some pesticide will enter the environment through means other than application. For instance, a certain amount of spillage on the ground appears to be unavoidable when large quantities of pesticides have to be handled for storage, formulation and transfer into application equipment. In light of this, areas where such spillage is likely to occur (i.e. formulation and transfer sites) should be well prepared to contained spills to avoid endangering ground water.

15. To the extent practical, wildlife censuses should be performed prior to large control campaigns in order to provide accurate pre-treatment counts for use in assessing environmental impact.

ANNEX A

STATEMENT OF WORK

ARTICLE IV - STATEMENT OF WORK

General

The evaluation will have three main objectives: a) assess USAID's response to the GOM's call for emergency assistance; b) assess project achievements; and, c) detail lessons learned.

The stated Outputs of the Project are:

(1) enhanced GOM capacity to control desert locust invasions with appropriate aircraft and pesticides;

(2) improved strategic-planning and tactics of control operations, including preparation for appropriate responses north of the Atlas Mountains, if necessary;

(3) improved efficiency of operations -- survey, treatment and communications;

(4) improved GOM capacity for the management and monitoring of environmental, safety and health aspects of control operations;

(5) trained GOM personnel in the proper handling and use of pesticides; and,

(6) improved efficiency of control operations, including ground surveillance, ground-to-air communications, and control strategies.

The Contractor shall:

(a) evaluate the effectiveness of the Project in meeting the output-level objectives stated above, as well as their continued relevance in light of the implementation experience of the Project and the changing needs of the Crop Protection Service;

(b) evaluate the Project's progress in meeting its purpose-level objectives, that is, to assist the GOM to control desert locusts;

(c) provide a general assessment of the effectiveness of the Project in meeting its goal-level objective, that is, to protect Moroccan crops and livestock from the locust plague in ways consistent with protecting the health and well-being of the people and the environment of Morocco; and,

(d) clearly document the "spin-off" activities that have occurred and address appropriateness and sustainability of these activities in the context of major future Moroccan pest control programs.

In the course of this work, the Contractor shall identify constraints or potential problems that might have delayed or impeded the achievement of these various objectives.

Specific Concerns and Issues

RELEVANCE: Are the development constraints the project was initially designed to address major problems that are germane to the current development strategies supported by A.I.D.?

EFFECTIVENESS: Did the project progress satisfactorily toward its stated objectives?

EFFICIENCY: Are the benefits of the project being generated at an acceptable cost compared with possible alternative approaches to accomplishing the same objectives?

IMPACT: What positive and negative effects are resulting from the project? In addition to the economic impacts resulting from improved locust control operations, what environmental impacts have occurred or might be anticipated to occur as a result of project activities, e.g., pesticide application activities, management of excess USAID-financed pesticide stocks? What actions are recommended to mitigate any such negative environmental impacts?

SUSTAINABILITY: Did the Project result in sustainable development impacts, i.e., improvements in the GOM capability to effectively deal with future locust outbreaks? Does the GOM now have the capacity to address emergency pest problems using control means developed through the Project? What activities initiated under the Project can and should properly continue after A.I.D. funding has stopped?

LESSONS LEARNED: What can be identified as useful lessons or insights gained which may be applicable to the design of future projects of a similar nature; e.g., is it realistic to expect institutional development and benefit sustainability from what is basically designed as a one-time, disaster control effort? To what extent can and should the short-term and longer-term objectives be combined?

Methodology

The Contractor shall utilize an evaluation methodology that shall consist of a documentation review (both Project documentation as well as other, locust control-related materials) and personal interviews with key persons at involved institutions: AID/W, OFDA, USAID/Morocco, the Centre National de la Lutte Anti-Acridienne (CNLAA), Gendarmerie Royal and the Direction de Protection des Vegetaux, Controle Technique, et Repression des Fraudes (DPVCTRF). The Contractor shall also conduct interviews (both individual and group interviews) in Morocco with staff of other institutions concerned with the function of the Morocco Locust Control effort.

This exercise is expected to take approximately 21 working days for the full team: 2 working days in Washington, D.C. for orientation and review of materials there, and 18 working days in Morocco (six day work week is expected at no premium pay). The team leader will be expected to spend an additional 3-5 days in-country revising the initial draft report based on USAID and GOM comments. Therefore, the level of effort for this activity is 75 person-days.

ANNEX B

LIST OF PERSONS CONTACTED

ANNEX B

LIST OF PERSONS CONTACTED

NAME	FONCTION	ORGANISATION
WASHINGTON		
Tejeda Felipe	Vice President	Development Assistance Corporation (DAC)
O'Brien Louis	Program Officer	Development Assistance Corporation (DAC)
Segarra Alex	Entomologist	USAID/NE/DR/PIE
Huden Gudrun	Environmental Specialist	O.F.D.A. USAID
Showler Allen	Entomologist	Bureau of Res & Develop, AID/Washington
Thibeault Robert	Director	Office of International Major Projects, U.S. Dept. of Commerce
Knausenberger W.	Envir. analyst & advisor	USAID/Africa Bureau Office of Analysis, Research & Tech. Support
Jensen Janice K.	Chemist	Office of Pesticide Prog. US Envir. Prot. Agency
Desmond Kathy	President	Community Information Exchange
MOROCCO		
Layid Moha	Lt-Colonel	Coordinateur PCC Gendarmerie Royale
Arifi Abdelaziz	Director	Plant Protection D.P.V.C.T.R.F. Mara
Lakhdar Rachid	Deputy Director	Plant Protection D.P.V.C.T.R.F. Tel. 77.10.78 Rabat
Ghaout Said	Agent	Plant Protection D.P.V.C.T.R.F.
Amhaouch Mohamed	Royal Army	Locust Control Operation, PCC
Kitts Joseph	Locust coordinator	USAID/Morocco
Chandler Dennis	Director	USAID/Morocco
Lowenthal James	Deputy Director	USAID/Morocco

LIST OF PERSONS CONTACTED

(continued)

NAME	FONCTION	ORGANIZATION
Uphaus Charles	A.D.O.	USAID/MoroccoSchamper,
John	Deputy A.D.O.	USAID/Morocco
Loken, R. Eric	Envir. Officer	USAID/Morocco
Thomas, Bill	Envir. Analyst	Africa Bureau, AID/W Tel. (703) 235-3837 Fax. (703) 235-3805
Ben Halima Thami	Director	Centre National de Lutte Antiacridienne, NLCC, Ait Melloul Tel. 312-21 Agadir
Mouhim Ahmed	Chef de Bureau	Bureau de l'intervention et de la recherche, NLCC, Ait Melloul
Dliou Ahmad	Inspecteur PV	Chef PC Regional de Guelmim
Boudadi Lahcen	Director	Lycee Agricole d'Ouled Teima, Direction de l'Enseignement Agricole et de la recherche, MARA
Laarabi, Ahmed	Agent	Direction Provision Agricole, NLCC, Ait Melloul
Laaberki, Ahmed	Director	Laboratoire Officiel d'Analyses et de Recherche Chimiques, Casablanca Tel. 30.20.07 Casa Fax. 30.19.72 Casa
Tarhi, Moustafa	Responsible	Pesticides section, Laboratoire de Casa
El-Guermaz, Omar	Chemist	Responsible of Industrial section, Laboratoire de Casablanca
Hajoui, Hassan	Colonel	Inspecteur general, Civil Protection, Ministry of Interior
Rabbaa, M.	Chef	Division des Etudes et de la Coordination, Ministry of Interior

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LIST OF PERSONS CONTACTED

(continued)

NAME	FONCTION	ORGANIZATION
Halim,	Colonel	Inspecteur Inspection des services de secours, Ministry of Interior
Amalo,	Lt-Colonel	Chef Division de la Prevention et reglement. Ministry of Interior
Hmimech Mehdi	Chef	Division des services administratifs, Ministry of Interior
Elharmouchi, A.	Chef	Bureau des Pesticides et de l'Homologation, Crop Protection Service Tel. 77-15-47 Rabat
El-Haje, Hachem	Res. Rep. a.i.	FAO representation in Morocco Tel. 76.58.65 Rabat Fax. 76.64.68 Rabat
Bouchanine, A.	Prog. Officer	FAO representation in Morocco
Loubaris, Hassan	Aministrator	Dir. de l'Aeronautique Civile, Ministere des Transports
Aghori, Abdeslam	Chef de Service	Service des Etudes d'infrastructures, Direction des Bases Aeriens, Ministere des Transports
Mahjour, Jaouad	Chief Medical Officer	Ministry of Health
Beraoud, Lahcen	Pilot, Captain	Supervisor, Airplane and Helicoptor operations, Gendarmerie Royale

ANNEX C

ITINERARY OF EVALUATION TEAM

ANNEX C

MISSION ITINERARY

DATE	LOCATION	ACTIVITY
26-FEB-92 (Wed)	Washington, D.C.	- Arrival of all team members in Washington.
27-FEB-92 (Thu)	Washington, D.C.	- Meeting with DAC personnel. - Team members meeting. - Meeting with USAID & OFDA officers.
28-FEB-92 (Fri)	Washington, D.C.	- Meeting with USAID/Africa Bureau officer. - Meeting with US EPA officer. - Meeting with an OTA report collaborator.
29-FEB-92 (Sat)	Washington, D.C.	- Team meeting. - Travel of team members: Departure from Washington
01-MAR-92 (Sun)	New York Rabat, Morocco	- Arrival of 3 team members in New York (flight delay) - Arrival of 2 team members in Rabat, Morocco.
02-MAR-92 (Mon)	Rabat, Morocco	- Arrival of 3 team members in Rabat, Morocco. - Meeting with USAID officer - Reviewing documents
03-MAR-92 (Tue)	Rabat, Morocco	- Meeting with USAID officer - Team meeting - Documents review
04-MAR-92 (Wed)	Rabat, Morocco	- Meeting with Moroccan officials at the PCC - Meeting with the USAID Director and officers - Meeting with a Plant Protection Officer - Team meeting
05-MAR-92 (Thu)	Rabat, Morocco	- Meeting with Moroccan officials at the PCC - Contact with Plant Protection agent - Documentation review
06-MAR-92 (Fri)	Agadir, Morocco	- Travel from Rabat to Agadir - Meeting with Moroccan officials and visiting the Locust Control Center
07-MAR-92	Agadir/Tiznit/	- Meeting with an official from the LCC

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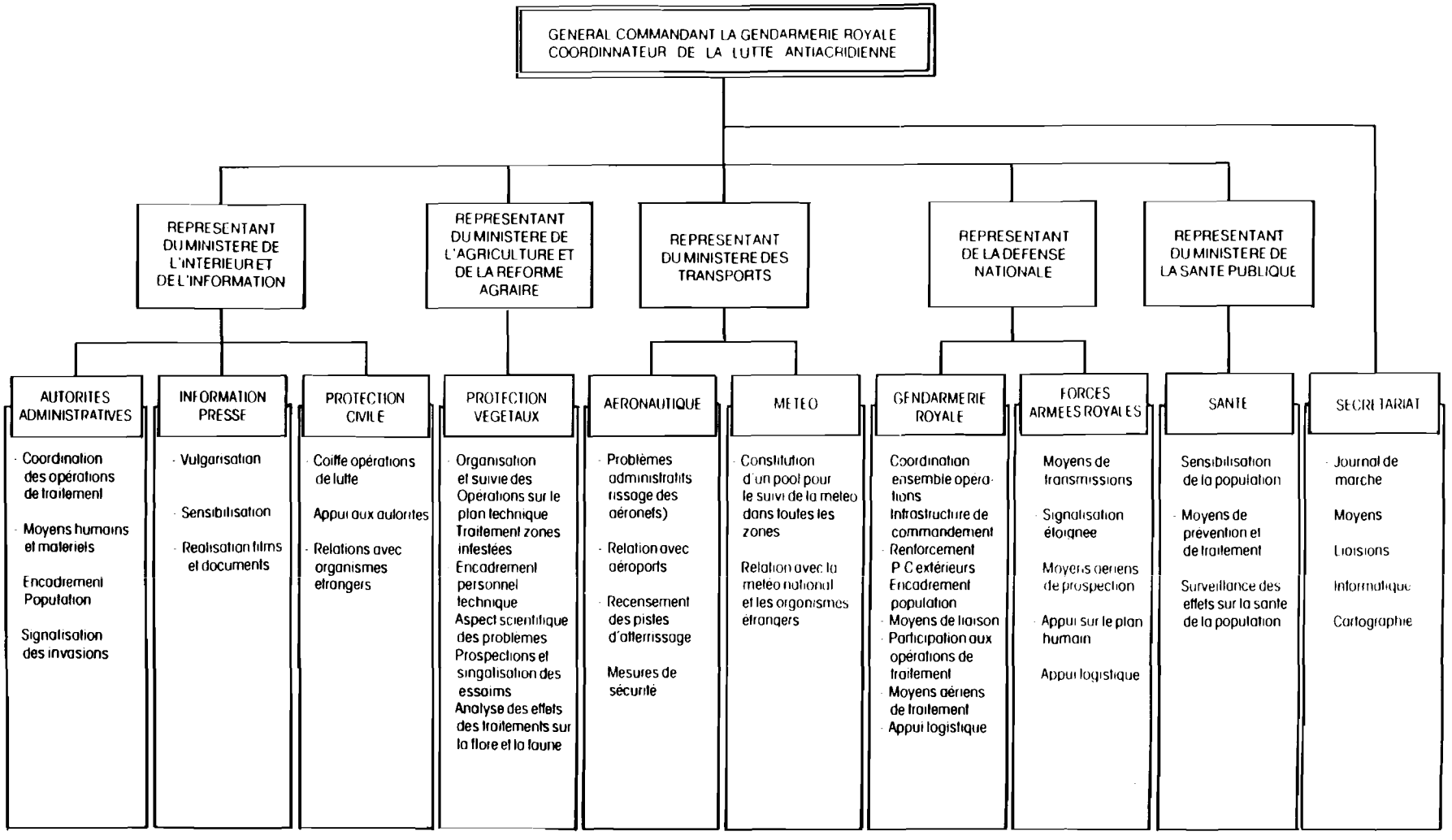
(Sat)	Guelmim/Agadir	of Ait Melloul - Visit of pesticide storage site at Tiznit - Site visit to Guelmim and Sidi Ifni (treated sites)
08-MAR-92 (Sun)	Agadir/Taroudant/ Agadir	- Visit of pesticide storage site at Taroudannt - Team meeting
09-MAR-92 (Mon)	Agadir (2 members)	- Meeting with Officials of the National Locust Center
	Agadir/Tata (3 members)	- Visit of operational zones and air strips - Visit the pesticide storage site at Foum-El-Hussein
10-MAR-92 (Tue)	Agadir (2 members)	- Meeting with Officials of the National Locust Center
	Tata/Agadir (2 members)	- Visit of operational zones and routes of invasions
	Tata/Ouarzazate (1 member)	- Survey of the terrain and operational zones
11-MAR-92 (Wed)	Casablanca (2 members)	- Visit the "Laboratoire Officiel de Casablanca"
	Ouarzazate (1 member)	- Visit the pesticide storage site at Boumalne Dades
	Agadir/Rabat (2 members)	- Return to Rabat
12-MAR-92 (Thu)	Rabat (4 members)	- Meeting with Officials of the Crop Protection Service
	Ouarzazate/Rabat (1 member)	- Return to Rabat
13-MAR-92 (Fri)	Rabat (2 members)	- Meeting with Officials of the Health Ministry
	Rabat (3 members)	- Meeting with officials of the Ministry of Interior
	Rabat (1 member)	- Meeting with officials from Crop Protection Service
	Rabat (1 member)	- Meeting with a "Pesticide Registration" agent
14-MAR-92 (Sat)	Rabat	- Report writing
15-MAR-92 (Sun)	Rabat	- Report writing

16-MAR-92 (Mon)	Rabat	- Team meeting - Meeting with FAO Resident representative and Program Officer
17- MAR-92 (Tue)	Rabat	- Team meeting - Meeting with officials of Ministry of Transport
18-MAR-92 (Wed)	Rabat	- Team meeting - Preparation of draft report
19-MAR-92 (Thu)	Rabat	- Evaluation debriefing to USAID/Morocco - Team meeting
20-MAR-92 (Fri)	Rabat	- Evaluation debriefing and recommendations to GOM officials at PCC - Team meeting
21-MAR-92 (Sat)	Rabat	- Team meeting - Wrap-up of Draft report - Meeting with USAID/M officer - Departure of team members from Morocco
23-MAR-92 (Mon)	Washington, D.C. (Team Leader)	- Finalize editing of the evaluation report at DAC
to		
27-MAR-92 (Fri)	Washington, D.C. (Team Leader)	- Finalize printing of the evaluation report at DAC

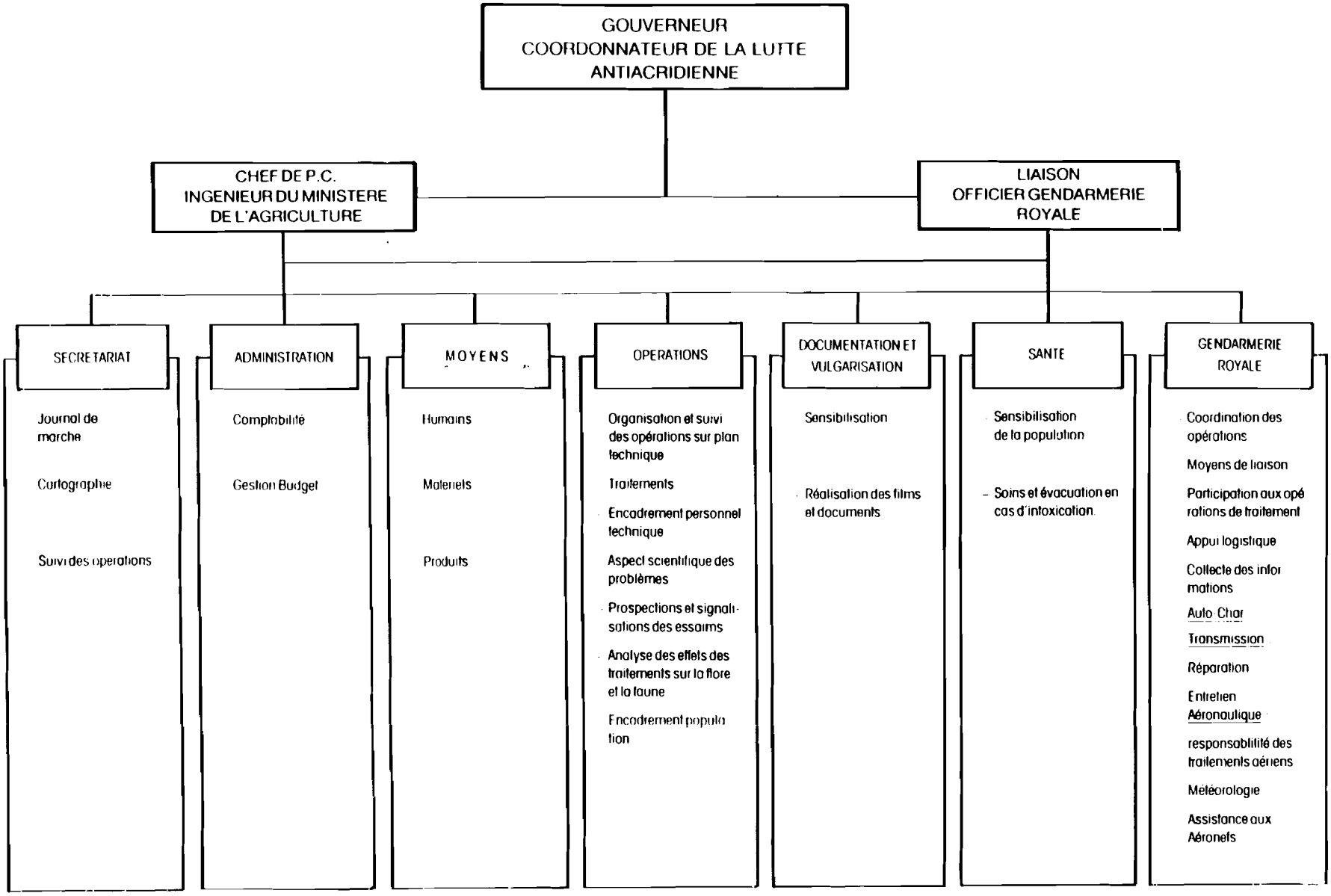
ANNEX D

ORGANIZATIONAL CHARTS

ORGANIGRAMME DU P.C. CENTRAL DE LA LUTTE ANTIACRIDIENNE



ORGANIGRAMME D'UN P.C.



ANNEX E

PROJECT INPUTS

Annex E

A. May 15 to June 30, 1988

1.	Aircraft - Two Turbo Thrush	Provided
	Rental Flying Hours Logistical Specialist	
2.	Insecticide	
	None	
3.	Health - Monitoring and Safety Equipment	Provided
	Cholinesterase Testing Kits (15 kits) Technical Assistance for Testing Kits (1 PM) Protective Clothing (200 sets)	
4.	Logistical Commodities	Provided
	Radios (40) Field Marking and Surveillance Other	
5.*	Assessments, Evaluation and Training	Provided
	Locust Expert/Ecologist (2 PM) Pesticide Management/Safety Expert (1 PM)	
6.*	Aircraft Rental for Three Month	Provided
7.	Vehicles	Provided
	(2 Landrovers, 4-Wheel-Drive with Radio)	

* **Incurred during July - September timeframe**

B. October 1988 - January 1989

1.	Aircraft - Two Turbo Trush Aircraft	Provided
	Rental Flying hours Logistical Expert Demobilization	
2.	Insecticide	Provided
	Malathion 400,000 liters Sea Freight	
3.	Spray System for Bell 205 Helicopters	Provided
	Procurement of Spray Systems Technical Expert	

4. Project Coordinator for both Campaigns (June - January)

5. Contingency

C. January 1989 to June 30, 1989

1. Aircraft — Provided

   a. Two Turbo-Thrust aircraft through June
   b. Two DC-7 aircraft from March through June
   c. Aircraft Contract/Logistical Specialist (10 pm)

2. Insecticide — Not provided

   a. 400,000 liters of malathion, bendiocarb or dursban
   b. Sea Freight

3. Environment, Health and Safety Commodities — Provided

   a. Cholinesterase Kits (20)
   b. Protective Clothing (2000)
   c. Fire Equipment
   d. Monitoring Equipment
   e. Other

4. Logistic Commodities — Provided

   a. Drum Disposal
   b. VHF Radios (12)
   c. HF Radios (10)
   d. Drybreak Systems (20)
   e. Greenness Maps
   f. Tank Trailers — Not Provided
   g. Other

5. Training and Technical Assistance

   a. Operations and Improvement Assistance

      1. Evaluation of Aircraft (DC-7 and Turbo) Application (1 PM) — Provided
      2. Pilot and Mechanic Training (15 PM) — Not Provided
      3. Radio Communication Training (2 PM) — Not Provided
      4. Prospection and Survey Training (2 PM) — Not Provided
      5. Helicopter Spray System Re-design (2 PM) — Not Provided

   b. Environmental, Health and Safety Assistance

      1. Environmental Monitoring and Assessment (12 PM) — Provided
      2. Evaluation of Large Aircraft (DC-7) Environmental Impact (1 PM) — Not Provided
      3. Insecticide Management Training (1 PM) — Not Provided
      4. Insecticide Testing and screening (2 PM) — Not Provided
      5. Cholinesterase Health Specialist (1 PM) — Provided

   c. Project Assessment, Campaign Assessment and Strategy (6 PM) — Not Provided

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D. October 1989 - June 1990 Campaign

1.	Aircraft	Not Provided
	a. Two Turbo-Thrush b. Two DC-7 c. Aircraft Contract/Logistical Special	
2.	Insecticide (800,000 liters)	Not Provided
3.	Environmental, health and Safety Commodities	Not Provided
4.	Logistic Commodities	Provided
5.	Training and Technical Assistance	Provided
6.	Project Coordination	Provided

E. Project Audit

ANNEX F

PESTICIDE INVENTORIES

STOCK DES PESTICIDES EN LITRES PAR P.C.R.

ANNEX F

SITUATION DU 10/03/92

P.C.R. NATURE DE PRODUITS	AIT MELLOUL (1)	GUELMIM (1)	TATA (1)	LAAYOUME (2)	DAKHLA (1)	ERRACHIDIA (2)	OUARZAZATE (2)	BOUARFA (2)	KHENIFRA (2)	MISSOUR (2)	TAZA (2)	OUJDA (2)	MARRAKECH (2)	TOTAL	ORIGINE
DDVP TECHNIQUE ULV															
- 97 %	90,670	0	0	0	0	0	0	0	0	0	0	0	0	90,670	CIBA GEIGY SUISSE
- 96 %	307,200	11,200	0	0	0	1,200	0	0	0	0	0	0	0	319,600	DENKA HOLLAND
- 20 %	33,200	87,200	50,200	78,180	8,000	68,800	71,800	67,500	12,800	15,800	10,350	9,750	2,000	515,580	
- 15 %	0	7,000	0	0	0	0	0	0	0	0	0	0	0	7,000	
- 4 %	21,000	125,400	61,800	49,220	29,000	61,800	34,600	90,920	16,200	11,600	13,600	35,325	6,590	557,055	
	452,070	230,800	112,000	127,400	37,000	131,800	106,400	158,420	29,000	27,400	23,950	45,075	8,590	1,489,905	
MALATHION ULV															
- 96 %	54,000	19,600	0	23,400	0	17,000	46,000	1,600	0	0	0	0	0	161,600	CHEMINOVA DANEMARK
- 96 %	48,000	24,200	41,000		0	0			0	0	0	0	0	113,200	CIANAMYO U.S.A.
(MALAGREX)															
- 95 %	142,200	37,200	4,400	0	0	0	0	1,400	0	0	0	0	3,200	188,400	CHEMINOVA DANEMARK
- 14 %	0	0	9,600	0	0	0	0	0	0	0	0	0	0	9,600	
	244,200	81,000	55,000	23,400	0	17,000	46,000	3,000	0	0	0	0	3,200	472,800	
FENITROTHION															
- 100 % ULV	200	280	0	400	0	200	6,800	1,200	0	0	0	0	1,000	10,080	CHEMINOVA DANEMARK
-100 % ULV	178,000	0	0	0	0	0	0	0	0	0	0	0	0	178,000	SUMITOMO CHEMICAL CO. LTD
(SUMITHION)															JAPAN (CALIOPE FRANCE)
- 50 % ULV	284,750	14,200	0	0	0	0	0	0	0	0	0	400	0	299,350	CHEMINOVA DANENARK
- 50 % E.C	24,500	0	0	0	0	0	0	0	0	0	0	0	0	24,500	FINLAND
- 35 % ULV	0	300	0	0	0	0	0	0	0	0	0	0	0	300	
- 10 % ULV	0	0	0	2,000	0	0	0	0	0	0	0	0	0	2,000	
	487,450	14,780	0	2,400	0	200	6,800	1,200	0	0	0	400	1,000	514,230	
DECIS															
- 12.5 ULV	1,650	4,875	0	0	0	0	7,350	0	2,450	0	0	0	0	16,325	* PROCIDA GROUPE RUSSEL
- 25 E.C	99,200	0	0	1,600	0	0	1,625		1,350	0	125	5,000	7,580	116,480	*UCLAF FRANCE (SOTRACHIM)
- 2.5 ULV	2,400	0	0	0	0	0	0	0	0	0	0	0	0	2,400	
	103,250	4,875	0	1,600	0	0	8,975	0	3,800	0	125	5,000	7,580	135,205	
KARATE															
- 4 % ULV	96,350	5,875	0	0	0	325	0	0	0	0	0	0	0	102,550	*I.C.I. ANGLETERRE
- 5 % E.C	18,500	0	0	0	0	0	0	0	0		0	0	0	18,500	* (MARBAR)
- 2 % ULV	4,600	0	0	0	0	0	0	0	0	0	0	0	0	4,600	
	119,450	5,875	0	0	0	325	0	0	0	0	0	0	0	125,650	
DIAZINON ULV	0	0	0	1,800	0	0	0	0	0	0	0	0	0	1,800	
BASUDINE 60% E.C.	995	0	0	0	0	0	0	0	0	0	0	0	0	995	
DALLA E.C	19,600	0	0	0	0	0	0	0	0	0	0	0	0	19,600	AGRIPLANSA ESPAGNE
TOTAUX	1,427,015	337,330	167,000	156,600	37,000	149,325	168,175	162,620	32,800	27,400	24,075	50,475	20,370	2,760,185	
SOLVANT "HAN"	2,524,000	0	0	0	0	2,000	0	0	0	0	0	1,130	0	2,527,130	EXXON CHEMICAL BELGIQUE
TOTAL GENERAL														5,287,315	

(1) CHIFFRES VERIFIES ET ACTUALISES PAR L'EQUIPE DE TRANSVASEMENT DU C.N.L.A.A. APRES PASSAGE DE LA COMMISSION DU P.C.C.

(2) CHIFFRES CONTENUS DANS LES P.V. DE LA COMMISSION DU P.C.C.

ANNEX F

B-Insecticides Non Utilisables (en litres)

ANCIEN STOCK	TIZNIT	B.IZAKARN	TAROUDA	A.CHAIB	AKKA	F.ELHISN	LAAYOUNE	DAKHLA	CASA	TOTAUX
DIVERS PESTICIDES MELANGES AU GASOI	n.a.	0	44,200	0	0	n.a.	44,200	n.a.	n.a.	88,400
H.C.H 15% (L)	165,000	0	272,400	0	0	50,000	5,000	5,000	0	497,400
H.C.H 10% (L)	114,000	0	113,000	0	8,200	36,000	0	0	0	271,200
H.C.H 3% POUDRE (KG)	32,350	2,000	271,440	0	0	0	0	2,000	151,000	458,790
SON APPAT (KG)	75,090	300,600	0	0	0	0	5,000	0	0	380,690

ANNEX G

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ANNEX G

BIBLIOGRAPHY

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